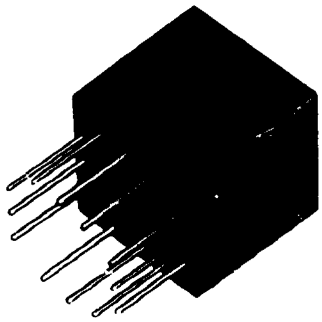
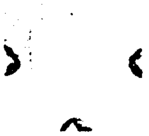
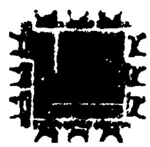
NINETEENTH QUARTERLY REPORT

MICRO-MODULE PRODUCTION PROGRAM







The object of the Micro-Module Production Program is to provide micro modular design and construction of electronic circuits, which will equip the U.S. Army with a broad new production potential for the construction of micro-miniature electronic equipment, offering a great reduction in size, weight and maintenance with improved reliability.

Period Covered — October 1, 1962 to January 1, 1963

MICRO-MODULE PRODUCTION PROGRAM

SIGNAL CORPS CONTRACT DA-36-039-SC-75968

SIGNAL CORPS SPECIFICATION SCL-6243 • MARCH 17, 1958

RADIO CORPORATION OF AMERICA

SURFACE COMMUNICATIONS DIVISION • DEFENSE ELECTRONIC PRODUCTS • CAMDEN 2, NEW JERSEY

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

HIGHLIGHTS OF THE NINETEENTH QUARTER

RELIABILITY STILL CLIMBING AFTER 19.3 MILLION ELEMENT TEST HOURS

Micro-modules fabricated under Program Extension II reached the level of 19,250,000 element-hours of operating life test during this quarter. Test results indicate a mean-time-between failure (MTBF) of 498,000 hours at 60% confidence for a 10-element module. The corresponding element failure rate is .020 percent per 1000 hours.

The level of reliability thus greatly exceeds the program goal of 75,000 hours MTBF.

PEM INCREASING INVENTORY OF COMPONENTS

AEROVOX has demonstrated pilot-run production and performance capability for multi-layer capacitor types of at least 7,000 per month. It has also completed construction of a tinning facility capable of processing 40,000 elements per month on an eight-hour work shift, as compared with a required rate of 35,000 per month.

CORNELL-DUBILIER completed its preproduction program and the fabrication of 2,400 pilot-run single-layer capacitors.

MICROLECTRON completed its pilot-production of semiprecision resistors.

PREPRODUCTION RUNS CONTINUING

Preproduction testing of trimmer capacitors was completed by Centralab. ASTRON and SPRAGUE received approval to start fabrication of preproduction samples of electrolytic capacitors.

The fabrication of 2,700 preproduction metalized substrates by COORS PORCELAIN is in progress. A pilot-production run of 23,000 units will start next quarter.

A preproduction report on semiprecision resistors was submitted by CTS; pilot-run production will start next quarter.

TEXAS INSTRUMENTS and SPERRY SEMICONDUCTOR are continuing with their respective transistor preproduction programs. FAIRCHILD, HUGHES and MICRO-SEMICONDUCTOR will start their diode preproduction programs early next quarter.

OTHER COMPONENT HIGHLIGHTS NOTED

RADIO INDUSTRIES and CAMBRIDGE THERMIONIC Corp. have demonstrated a capability to fabricate i-f trimmer inductor elements made with commercial-grade ferrites and high-frequency "D" core fixed elements respectively.

MALLORY and PAKTRON will have a micro-module production capability by the end of the next quarter.

AN/PRC-51 RADIO SET deliveries to the Signal Corps during the quarter consisted of six transmitters and five receivers. These included three prototype transmitters and four prototype receivers, the remainder being engineering models.

All transmitters and receivers of the thirteen required AN/PRC-51 Radio Sets now have been delivered to the Signal Corps, after having performed satisfactorily in the specified acceptance tests.

The average receiver sensitivity of about 1.3 microvolts was over three times better than the required 4 microvolt sensitivity. All of the transmitters had output powers exceeding the required 100 milliwatts at 51 mc.

The MICROPAC COMPUTER mechanical assembly and wiring has been finished. Ninety percent of the circuit boards have been equipped with modules and tested in the breadboard computer. The clock pulse and timing level generators have operated satisfactorily with the MicroPac Computer.

The completely assembled MicroPac Computer has operated successfully over the ambient temperature range of 0°C to 45°C with the main chassis outside its transit case while performing the acceptance test program and a special memory test.

1. ABSTRACT

This abstract is a brief description of the significant accomplishments of the Surface Communications and Semiconductor and Materials Divisions of the Radio Corporation of America and of other industrial participants in the U. S. Army Signal Corps Micro-Module Program during the Nineteenth Quarterly period from October 1, 1962 through December 31, 1962.

1.1 STATUS OF PROGRAM PHASES

The Initial Program and Program Extension I have been successfully completed. All final-grade communications and digital equipment modules have been delivered under Program Extension II, Equipment. Most of the digital modules delivered for use in testing the MicroPac Computer had completed 6000 to 7000 hours of life test. All Group-C communication test modules, for Radio Set AN/PRC-51, have completed 2000-hour life tests; these life tests are being extended to 10,000 hours. Under Program Extension II, Production Engineering Measure, programs are in progress for micro-modules and for all component types, including capacitors resistors, inductors, transistors, diodes, and crystals.

1.2 PROGRAM DURING THE NINETEENTH QUARTER

Administration

Completion of the Equipment Phase and monitoring the progress of the Production Engineering Phase, both of Program Extension II, were given major emphasis during this quarterly period.

Capacitors — All subcontractors completed their production facilities and initiated preproduction test programs. The subcontractors for single and multilayer capacitors satisfactorily completed preproduction programs and initiated the pilot-production run and acceptance test phase.

Aerovox has demonstrated performance and production capability for multilayer capacitor types from NPO to N2200 of at least 7000 per month. The variable capacitor subcontractor has completed the preproduction test program, and test data results are currently being evaluated pursuant to initiation of the pilot-production phase. The electrolytic capacitor manufacturers are currently completing preproduction element fabrication and are initiating the test phase. The metalized substrate facility is being perfected in order to improve yield rates.

Inductors — Life test on 100 Aladdin pulse transformers indicate further improvement is needed in insulation resistance. All of these units had an insulation resistance in excess of 10^5 megohms prior to the start of the life test. After 1200 hours of test 98 of the 100 units had an insulation resistance greater than 2×10^5 megohms. Two units shorted when subjected to the 100 rms-volt dielectric strength test. They had insulation

resistance values of 350 and 17 ohms between windings when measured with a low-voltage ohmmeter. The RCA minimum specification for insulation resistance is 1000 megohms. The remaining 98 units were returned to life test and completed 2000 hours.

Delevan has successfully completed its task on a low-frequency inductor of micro-module size and has a production capability for this unit.

Collins submitted 17 of the required 20 prototype samples. These samples were 455-kc i-f transformers designed to meet the requirements of RCA Purchase Drawing A-2016903. These units were inspected by RCA, S & MD, and were rejected because of several defects (discussed in Section 3. 2. 3 of this report).

Radio Industries has demonstrated a capability for producing i-f trimmer inductor elements made with commercial-grade ferrites. This subcontractor supplied 20 of these prototype microelements made with Molecular Dielectrics glass-mica substrates. The units are being processed to develop reliable module-assembly and encapsulation processes.

Cambridge Thermionic Corporation has demonstrated capability to fabricate final-grade, high-frequency, "D" core, fixed inductor elements. The data on about 100 microelements showed that they met the inductance uniformity target of ±5 percent and bettered the ±15 percent unloaded-Q uniformity target by considerable margin. Life-test and environmental microelements were assembled in test modules and returned to Cambridge Thermionic for final life and environmental test measurements.

United Transformer was given approval to proceed with final samples of its audio transformers of micro-module size. The minimum over-all microelement height that can be presently guaranteed is .4 inch.

Transistors — Texas Instruments, Inc. has successfully completed all Phase II requirements for the 2N705 germanium transistors. It is now fabricating 300 preproduction test elements for Phase III. Sperry Semiconductor has also successfully completed all Phase II requirements for the 2N328A alloy units, and has placed the 300 preproduction test elements required for Phase II on 1000-hour, high-temperature aging. General Electric fabricated and supplied the 2N335 grown-junction microelement transistors required for Phase II. It has fabricated 200 Phase II elements which are now in 1000-hour high-temperature aging.

Details of the ultrasonic cleaning programs are being written for approval. Approximately 25 devices will be selected from each semiconductor family.

Diodes — Fairchild's testing program on the 1N658 diode is near completion. Group-A and -B test data revealed some problem areas which are discussed in Section 3. 3. 2 of this report. Fairchild's technique for mounting diodes to wafers allows the microelement to be aged at temperatures up to 300°C without loosening the diode.

In the nearly completed Phase II testing program at MicroSemiconductor, the Group-B test results indicated that the only major problem involved the test fixtures for performing the shock and vibration tests. This problem was solved by a change which was subsequently standardized for application to all diode and transistor microelements.

Hughes completed its Phase II program. Storage life test failures of four units show that the problem area is one of faulty internal connections. Failure analysis is being conducted so that correction action can be recommended.

A new welding head has been designed for the welding of diodes to metalized wafers and an addendum to the standard land and lead specification has been written for weldable wafers. To date, the best materials for welding are, in order: platinum, palladium, nickel, Kovar, and silver. The optimum wafer consists of a .002-inch-thick nickel plating with a gold flash above the basic metalization. Results of the welding investigations are fully described in Section 3.3.2 of this report.

Micro-Modules — Communication modules have completed a total of 2,716,000 element-hours of test with no failures. The MTBF for a 10-element communication module is 296,000 hours at 60 percent confidence. Digital modules have completed 16,535,000 element-hours of test with three failures. The MTBF for a 10-element digital module is 527,000 hours at 60 percent confidence. The combined MTBF for a 10-element Program Extension II (including Task 36-1) module is 498,600 hours.

Most of the module assembly facilities have been installed and are presently being modified and refined where necessary. Mallory and Paktron indicate they will have production capability by March 1, 1963.

The AN/PRC-51 Radio Set

Tasks 27A and 25A, respectively covering the thirteen AN/PRC-51 Radio Sets and the micromodules therefor, have been completed except for the combined Formal Engineering Report which is currently in preparation. All required transmitters and receivers were delivered to the Signal Corps by the end of October, 1962.

MicroPac Computer

The MicroPac computer was completely assembled with all micromodule cards, memory stack and power supply, the logic checked and the system test initiated. The computer has operated successfully over the temperature range from +45°C to 0°C with the main chassis out of the transit case while performing the acceptance test program and a special memory test.

2. PURPOSE

2.1 THE MICRO-MODULE (MM) CONCEPT

The Micro-Module Concept is a new approach to electronic equipment design which is applicable throughout the electronic industry to both military and commercial equipments. The conventional methods utilized in the past, having been exploited virtually to the limits of their capabilities, leave much to be desired in regard to fulfillment of current and future needs for electronic equipment applications.

In order to correct this inadequacy, the Micro-Module Production Program was established jointly by the Army and RCA. RCA undertook the major responsibility of Leader Contractor for the utilization of the best that the entire electronic industry has to offer in skills, materials, and processes adaptable to this completely new concept of modular construction.

The Micro-Module Concept upon which the program is based is that of utilizing micro-elements with standardized dimensions of 0.31 x 0.31 x .01 inch, in lieu of conventionally shaped components. The standardized dimensions and shape permit high-density packing of micro-elements into micro-modules. By efficient grouping of the modules, compact subassemblies and complete equipments are formed which have a new order of volumetric efficiency. A component density of 600,000 parts per cubic foot is an ultimate goal of this program. This density represents an improvement as great as 10:1 in some equipments over conventional assembly techniques.

In constructing a micro-module, the required number and types of micro-elements are assembled by stacking them in accordance with the pertinent circuit function, the assembly is tested, and then encapsulated. Micro-modules are, in turn, assembled in aggregates representing equipment subassemblies in various arrangements depending on the equipment applications.

The selection of the most suitable basic materials, the eventual completely-controlled mechanized processing of these materials to form micro-elements, and the automatic assembly of micro-elements to form micro-modules will result in the attainment of a new high order of reliability without sacrifice of performance and with eventual savings in production and maintenance costs.

Reliability goals were established at 15,000 hours mean-time-to-failure for a 50 part module in the initial, basic program. There are certain reliability advantages inherent in the micro-module approach. The reduced dimensions and compact, rugged construction provide better capability of withstanding environment extremes. The space savings also permit application of redundancy and controlled environment within an equipment for greater reliability.

2.2 INDUSTRY PARTICIPATION

Neither RCA nor any other single company possesses or controls the many and diverse skills required for the successful accomplishment of the Micro-Module Program.

Rather, the key to its success has been the mutual cooperation between RCA, as the leader contractor, and the many companies of the entire electronics industry.

The components branch of the industry, particularly, has played a tremendous part in the Micro-Module Program in the development and manufacture of electronic micro-elements and micro-modules.

The effect of the Micro-Module Concept within the electronic industry will be an orderly and logical application of both known and, as yet, unknown techniques to this unique new dimension for both military and commercial electronic equipment.

2.3 PROGRAM

The authorization of work under the Micro-Module Program includes four divisions of effort whose descriptions and objectives are as follows:

A. The Initial Program: The objectives of this original program was the establishment of the feasibility and reliability of micro-modules and of a limited range and selection of micro-elements. Certain subassemblies, constructed with micro-modules, and a micro-modular version of the AN/PRC-34 helmet receiver were also required. This part of the over-all program has been completed.

B. Program Extension I: This extension has the purpose of providing extended ranges of values and different tolerances of micro-elements included in the initial program. Investigation and development of additional types of micro-elements needed for Extension II and improvement of processes for constructing micro-modules are also included. This part of the program also has been completed.

C. Program Extension II (Equipment): Includes development of Radio Set AN/PRC-51 including a helmet receiver, Receiver, Radio R-1018( )/PRC-51 and Transmitter, Radio T-792( )/PRC-51; the development of a General Purpose Computer Set for Digital Data (MicroPac); and the design and construction of micro-modules for the above equipments. Delivery of all the required Radio Sets was completed during this quarter. The MicroPac computer was undergoing acceptance tests at the end of the period.

D. Program Extension II (Production Engineering Measure): Under this extension processes, techniques, and facilities, are being planned and established for mechanized production of microelements and modules, which will be compatible with a production rate of 25,000 micro-modules per month.

3. NARRATIVE AND DATA

3.1 ADMINISTRATION

3.1.1 EQUIPMENT PHASE OF PROGRAM EXTENSION II

Major administrative emphasis continued upon completion of the MicroPac Computer and its test program under the Equipment Phase of Extension II. A full scale mock-up of the equipment and several contractual documents were delivered during this period. The latter included MicroPac Computer Diagnostic Routines, Instruction Manuals (Volumes 1, 2, and 3), Recommended Spare Parts List and an Interference Reduction Plan.

3.1.2 ORGANIZATION

Mr. Saul Stimler was appointed Manager of Micro-Module Projects.

3.1.3 DESIGN PLANS

Action II of TAR No. RCA-67 was received, approving revised Design Plans and associated Technical and Financial Progress Charts for PEM Tasks 28, 29, 30, 31, 32, 33, 34, 36, and 39. TAR No. RCA-69 was submitted and approved, eliminating delivery of 400 multilayer ceramic capacitors, Contract Item 6-2-A(1)a. TAR No. RCA-70 was submitted and approved, covering proposed revisions of RCA drawings for module types XM-708, XM-724, and XM-1084. The revisions are expected to yield improvements in microelement fabrication and in the design and assembly of preproduction micro-modules in Tasks 36-3 and 4 and on the pilot-run micro-modules of Task 39-1 and 2.

3.1.4 PROGRESS CHARTS

Submission of Financial and Technical Progress Charts was continued on a monthly basis.

3.1.5 REPORTS

The distribution list for quarterly reports was amended by TAR, USAERDL No. 62, Actions I and II of September 24, 1962 and by TAR, USAERDL No. 64, Actions I, II and III, completed November 20, 1962.

Monthly letter reports for September, October, and November, 1962 were prepared and issued.

A Status Report of the Production Engineering Measure on Micro-modules was prepared and submitted.

3.1.6 MISCELLANEOUS ITEMS

Task Meetings were held at regular intervals during the quarter and additional informal meetings were held as required for specific subjects or problems. A program status review was presented at the Administrative Meeting of October 31, 1962.

3.2 PASSIVE PARTS

3.2.1 CAPACITORS

3.2.1.1 PROGRAM EXTENSION II, PRODUCTION ENGINEERING MEASURE FOR CAPACITORS AND SUBSTRATES

Objectives and Status

The objective of this PEM is to establish microelement production facilities capable of supporting a micro-module production program. Subcontracts for multilayer ceramic capacitors, single layer ceramic capacitors, electrolytic capacitors, variable ceramic capacitors, and metalized substrate production facilities were approved, respectively, for the Aerovox Corporation, Cornell-Dubilier, both Astron Corporation and Sprague Electric Company, the Centralab Division of Globe Union, and Coors Porcelain Company.

All subcontractors completed their production facilities and initiated preproduction test programs. The subcontractors for single and multilayer capacitors satisfactorily completed the preproduction phase and initiated pilot-production run and acceptance test programs. The electrolytic capacitor manufacturers are currently completing preproduction element fabrication and are initiating the test phase. The variable capacitor subcontractor has completed the preproduction test program; test data and results are currently being evaluated pursuant to initiation of the pilot-production phase. The metalized substrate facility is being refined and improved in order to increase yield rates.

Hi-Q Division, Aerovox Corp., Multilayer Ceramic Capacitors

Prior to this quarterly period, Aerovox completed all preproduction facilities except for mechanized tinning. Parts were fabricated and the preproduction test program was satisfactorily completed.

During this quarterly period, Aerovox completed construction of the mechanized tinning equipment and initiated trial runs to establish optimum process cycles for tinning multilayer capacitors. Excellent solder coating was achieved on the nobel-metal-alloy metalization. The tinning equipment was inspected by RCA during the run-in period and was satisfactory, although the process cycle is not yet firmly established. A production-rate capability of approximately 40,000 elements per month for an eight-hour work shift is expected as compared with 35,000 required.

The equipment for notch metalizing is a rotating six-position "ferris" type wheel which is located above a fixed table with functional positions for: load-unload, first flux dip, first solder dip, second flux dip, second solder dip, excess solder removal (centrifugal), and solvent immersion cleaning bath.

Part numbers for 3260 of the required 7000 pilot-run elements were provided during this period. Aerovox initiated fabrication of these parts as soon as the mechanized

tinning equipment was completed. The authorization for producing the remaining 3740 parts is currently in process and Signal Corps approval is expected at the beginning of the next quarterly period. Group-A acceptance testing is also scheduled to start early next quarter. An engineering meeting will be held at that time to witness the initiation of these tests, and to demonstrate the production-rate capability of this facility.

As previously mentioned in the 18th Quarterly Report, PEM specifications for ceramic capacitors were revised and submitted to the Signal Corps for approval; the recommended changes in specifications for the pilot-run acceptance-test program for both multilayer and single layer capacitors were approved and authorized. Changes to the RCA purchase orders involving these specification revisions are in progress and will be released to the subcontractor at the beginning of the next period.

As described in the 17th and 18th Quarterly Reports, moisture resistance failures of the unencapsulated precision-type multilayer capacitors have been difficult to analyze for failure mechanism. During this period, Aerovox submitted six additional samples for moisture resistance test by RCA. These elements were incorporated into two test modules and subjected to the prescribed test with dc voltage applied to all units. Results of this test, indicating that the units met the test specifications, are shown in Table 3.2.1-1. Aerovox was advised of these test results and has initiated work to test another group of 12 capacitors in order to complete the preproduction test program.

TABLE 3.2.1-1
SUMMARY OF MOISTURE RESISTANCE TESTS PERFORMED BY RCA ON AEROVOX MULTILAYER CAPACITORS
(Encapsulated Elements 10 volts dc applied)

MODULE NUMBER	ELEMENT NUMBER	INITIAL VALUE			2 HOURS AFTER TEST		6 HOURS AFTER TEST		100 HOURS AFTER TEST	
		CAPACITANCE (pf)	DISSIPATION FACTOR %	INSULATION RESISTANCE (megohms)	Δ C[a] (%)	INSULATION RESISTANCE (megohms)	Δ C/C[a] (%)	INSULATION RESISTANCE (megohms)	Δ C[a] (%)	INSULATION RESISTANCE (megohms)
966	1	2824	.011	1500 K	+0.8	50 K	+0.8	15 K	+0.3	300 K
	2	2924	.011	1200 K	+0.2	400 K	+0.2	500 K	+0.1	2000 K
	3	2899	.010	900 K	+0.3	600 K	+0.3	600 K	+0.1	3000 K
967	4	2926	.018	1200 K	+0.5	600	+0.5	5000	+0.3	10 K
	5	2939	.011	1500 K	+0.1	300 K	+0.1	500 K	+0.1	1500 K
	6	2941	.009	1400 K	+0.2	300 K	+0.2	300 K	+0.1	1200 K

MT-39

Specifications: { Δ C/C: 5% (maximum)
Insulation Resistance: 1000 megohms (minimum)

(a) Percentage of the initial value.

Additional life-test results on precision and general-purpose multilayer capacitors were reported by Aerovox. A summary of these tests, which were initiated under the PEM Analysis Phase, are given in Table 3.2.1-2. Life tests are being continued by Aerovox to approximately 20,000 hours. Over five million component hours of testing at 85°C and twice-rated voltage have been accumulated with no failures having occurred.

TABLE 3.2.1-2
SUMMARY OF EXTENDED LIFE-TEST RESULTS ON AEROVOX CERAMIC CAPACITORS

CAPACITOR TYPE	NOMINAL CAPACITANCE	HOURS OF LIFE TEST	NO. OF UNITS*	ACCUMULATED COMPONENT HOURS**	NO. OF FAILURES
Precision (NPO)	2300 pf	14,000	203	2,876,700	0
General Purpose (C-90)	0.05 µf	12,000	173	2,240,100	0

MT-40

*Testing was started with 210 precision (NPO) units and 211 general-purpose (C-90) units. The periodic test handling resulted in some capacitor lead breakage. Units removed for this reason contribute to the figure for accumulated component hours up to their point of removal from the test. Units are measured every 1000 hours of testing.

**This test is being conducted at 85°C with an applied voltage of 100 volts dc which is twice the rated voltage.

Hi-Q Division of Aerovox Corporation, Extended-Temperature-Coefficient Range for Ceramic Multilayer Capacitors

Aerovox has designed a series of temperature-compensating, multilayer ceramic capacitors. Test samples were fabricated and life-testing of bare elements was completed. These elements have been incorporated into test modules and placed on life test.

During this period, Aerovox submitted test data indicating characteristics and performance obtained on the nine types of extended-temperature compensating multilayer ceramic capacitors. Figures 3.2.1-1 through 3.2.1-9 are curves showing the temperature characteristics of types N030, N080, N150, N220, N330, N470, N750, N1500, and N2200, respectively. Characteristic limits are those specified in MIL-C-20D with noted exceptions.

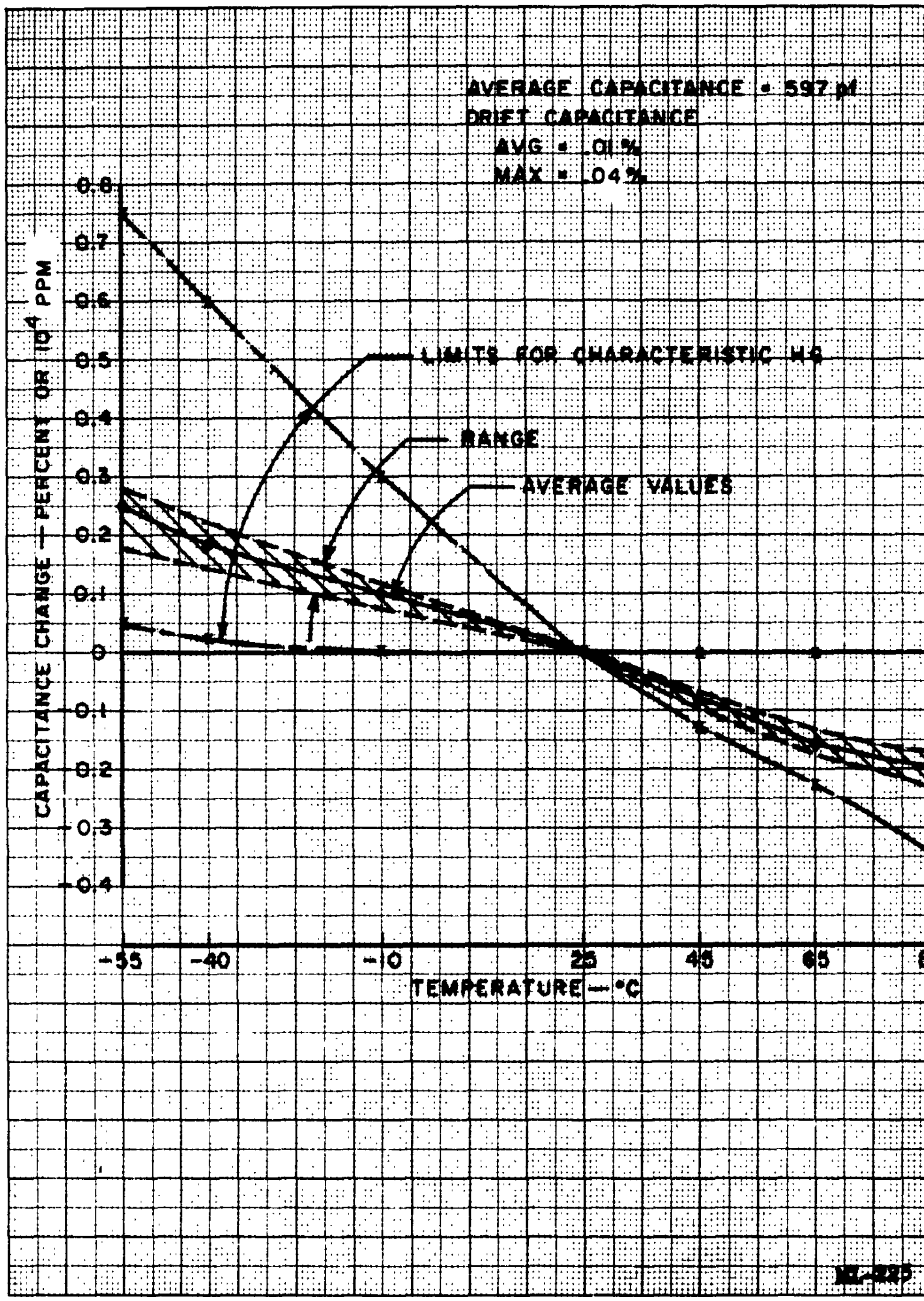


Figure 3.2.1-1. Temperature Characteristics for 12 N030 Aerovox Multilayer Ceramic Capacitors Tested at 1 Mc

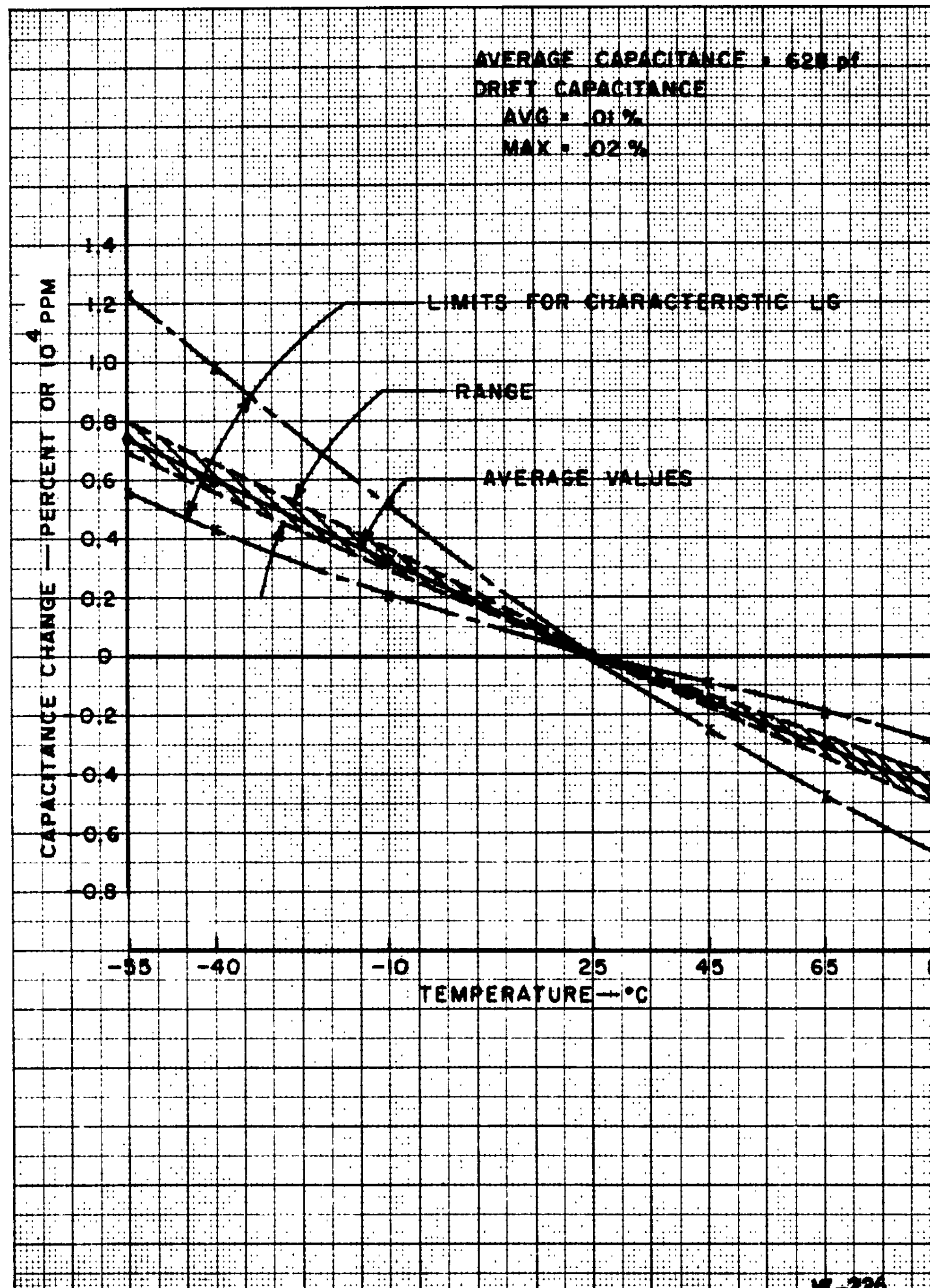


Figure 3.2.1-2. Temperature Characteristics for 12 N080 Aerovox Multilayer Ceramic Capacitors Tested at 1 Mc

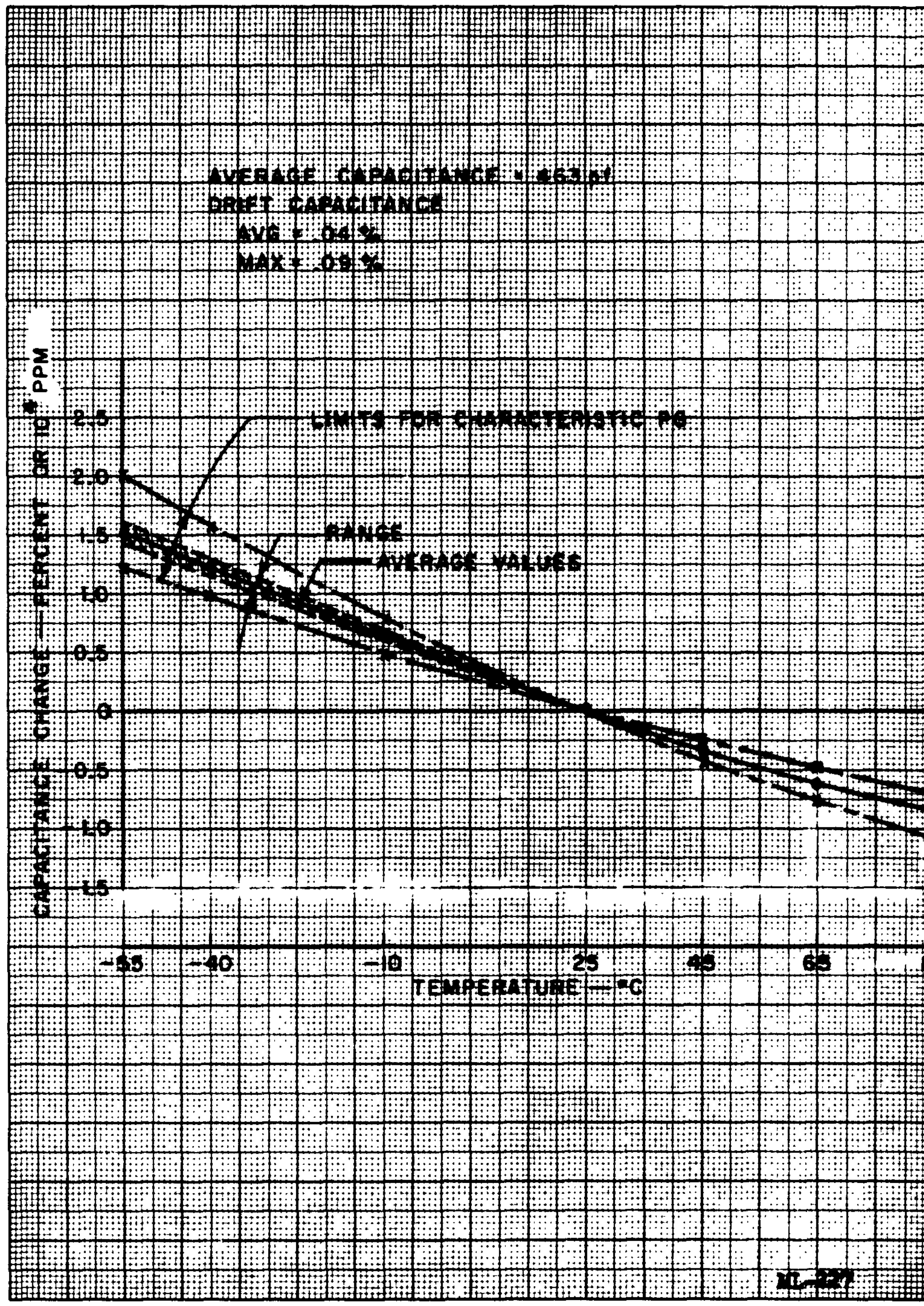


Figure 3.2.1-3. Temperature Characteristics for 12 N150 Aerovox Multilayer Ceramic Capacitors Tested at 1 Mc

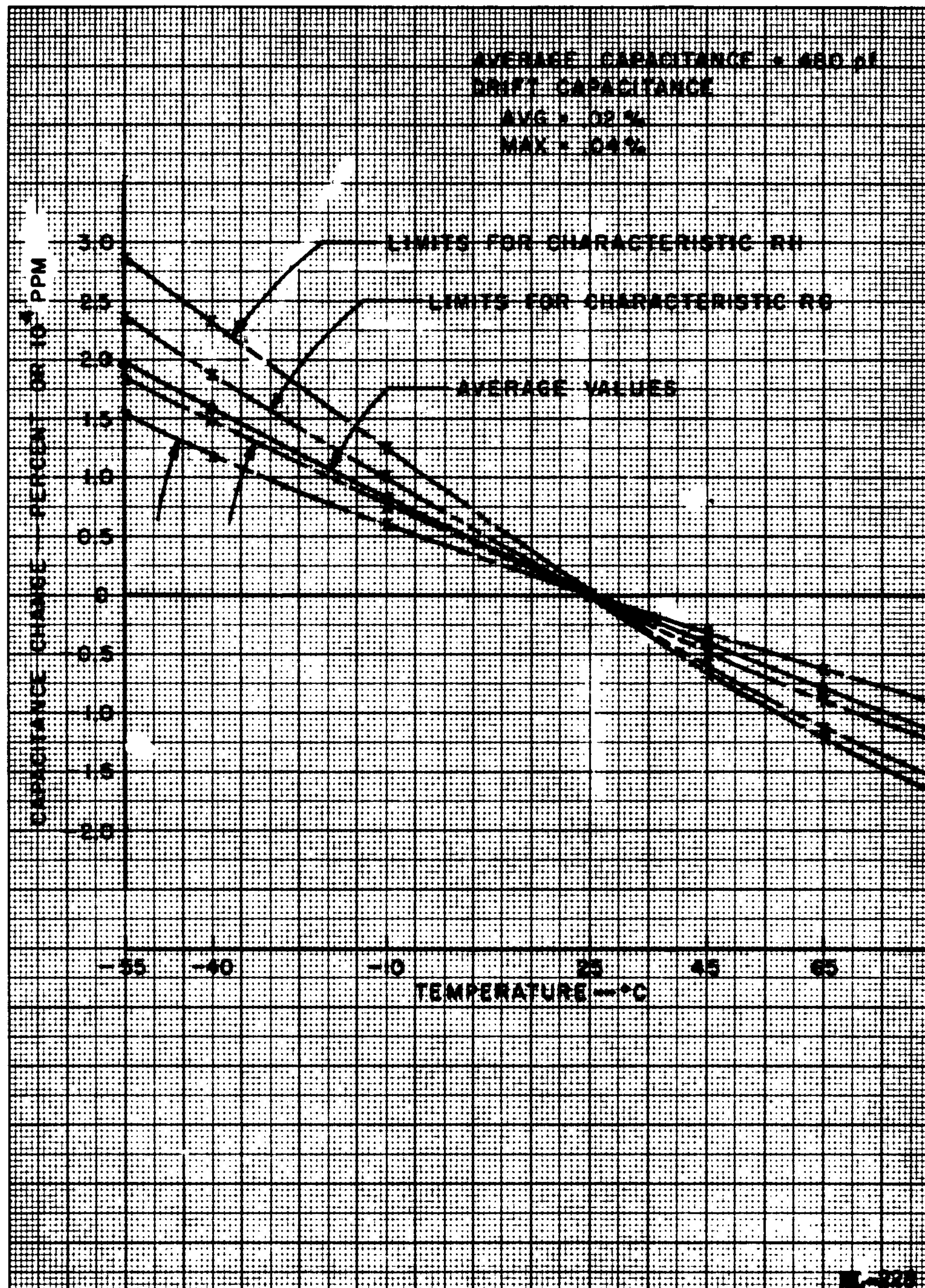


Figure 3.2.1-4. Temperature Characteristics for 12 N220 Aerovox Multilayer Ceramic Capacitors Tested at 1 Mc

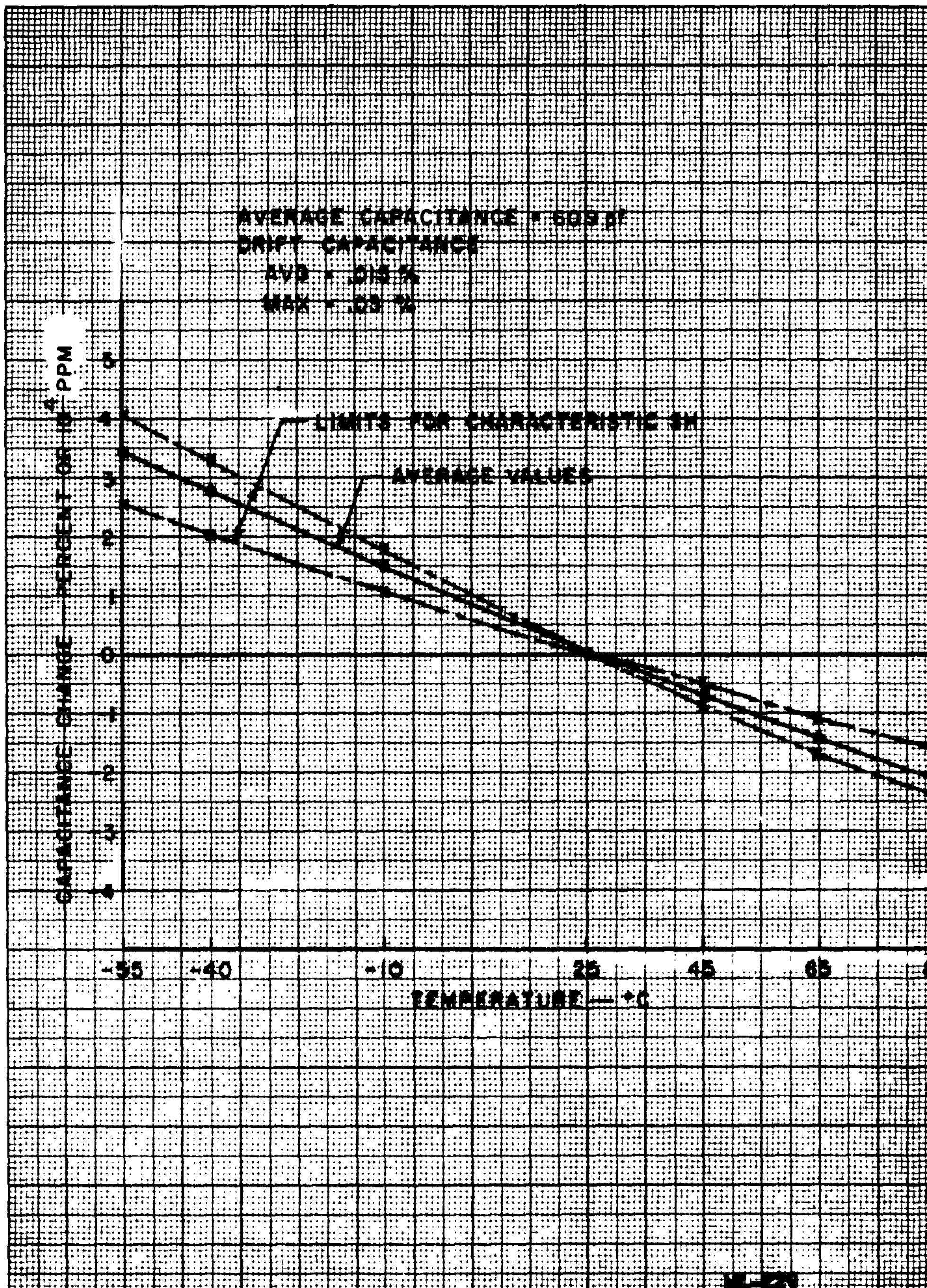


Figure 3.2.1-5. Temperature Characteristics for 12 N330 Aerovox Multilayer Ceramic Capacitors Tested at 1 Mc

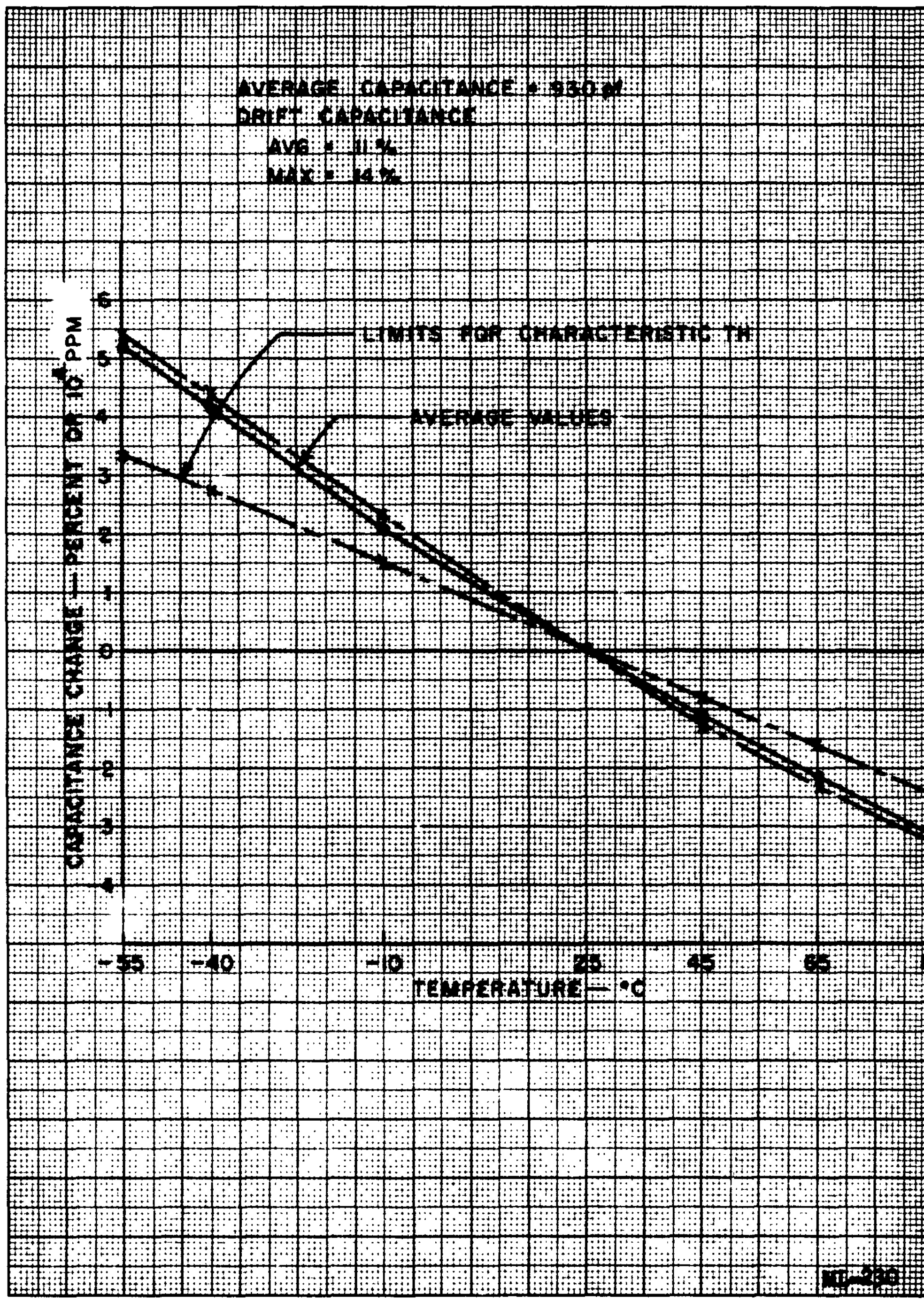


Figure 3.2.1-6. Temperature Characteristics for 9 N470 Aerovox Multilayer Ceramic Capacitors Tested at 1 Mc

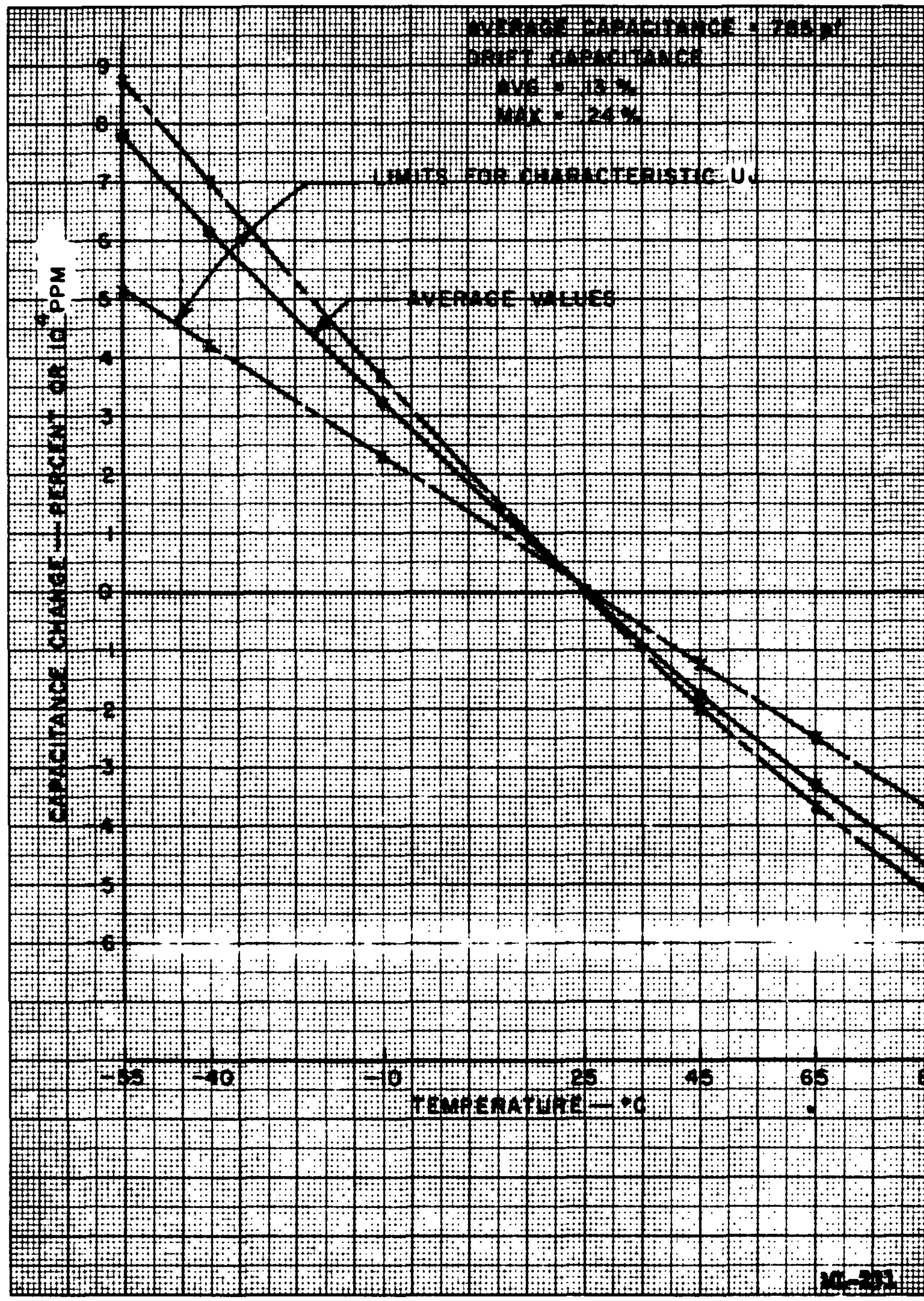


Figure 3.2.1-7. Temperature Characteristics for 12 N750 Aerovox Multilayer Ceramic Capacitors Tested at 1 Mc

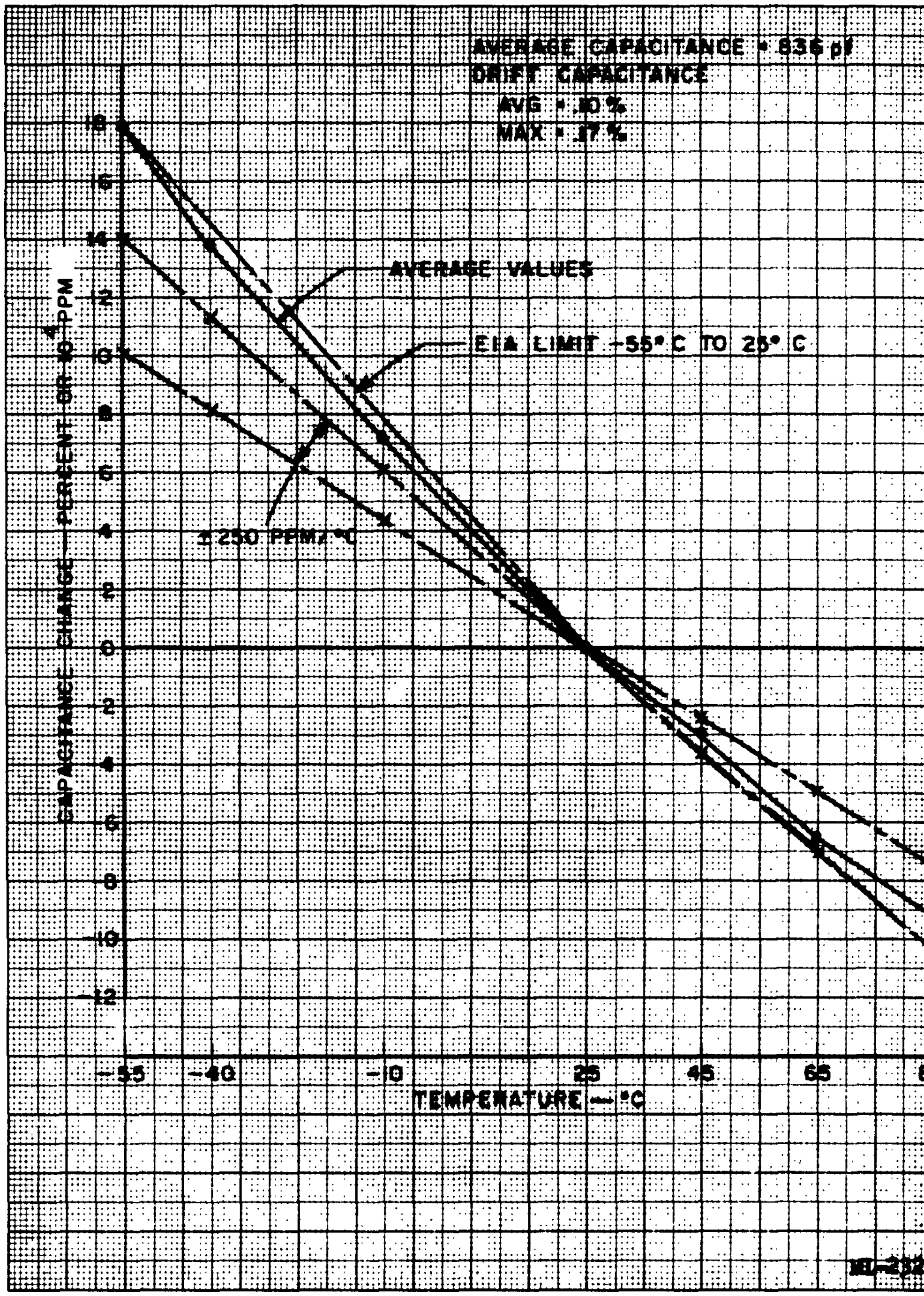


Figure 3.2.1-8. Temperature Characteristics for 12 N1500 Aerovox Multilayer Ceramic Capacitors Tested at 1 Mc

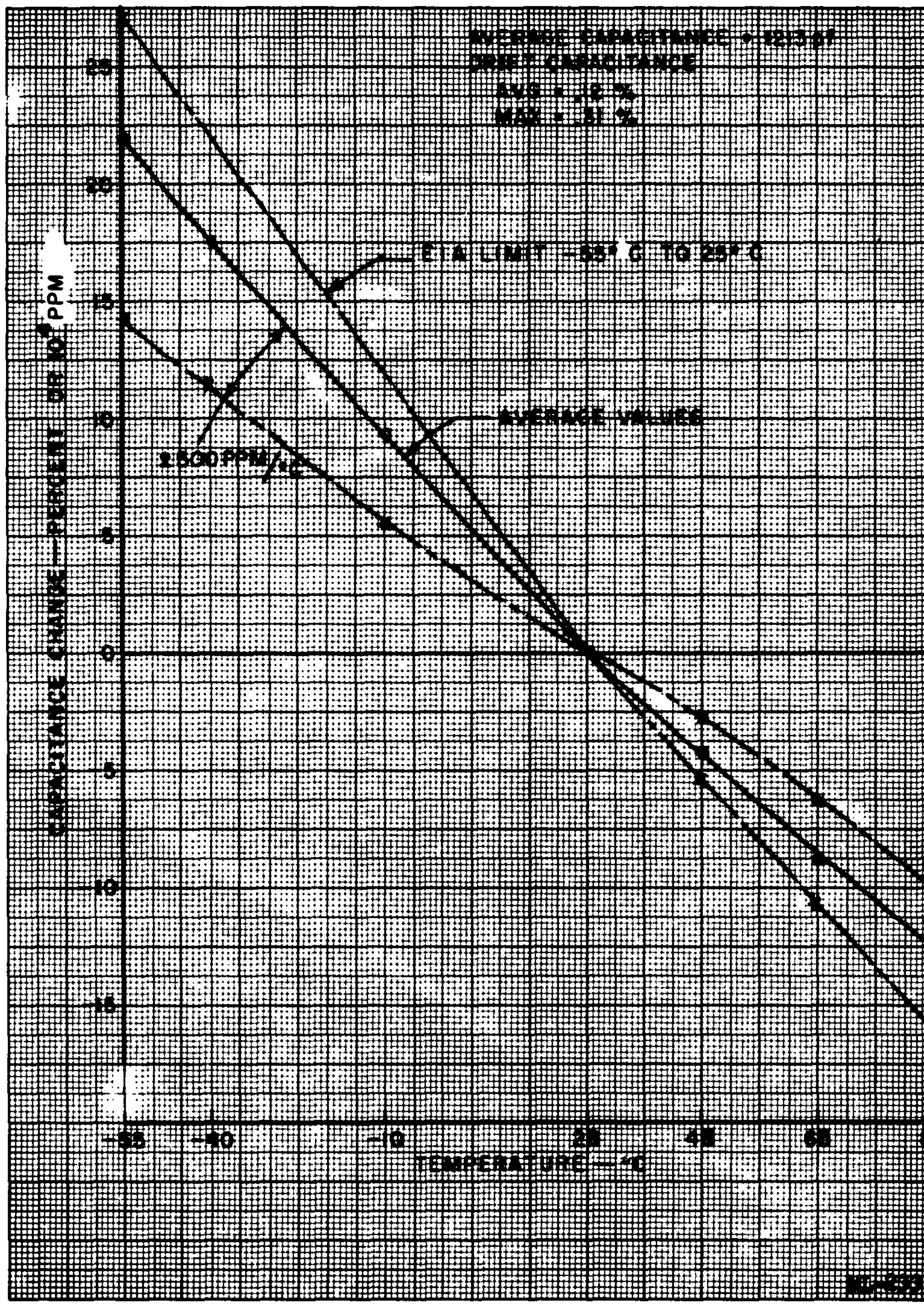


Figure 3.2.1-9. Temperature Characteristics for 11 N2200 Aerovox Multilayer Ceramic Capacitors Tested at 1 Kc

The following is a summary of the temperature characteristics for the nine types:

Figure No.	
3.2.1-1	N030 met Characteristic HG requirements.
3.2.1-2	N080 met Characteristic LG requirements.
3.2.1-3	N150 met Characteristic PG requirements.
3.2.1-4	N220 did not meet Characteristic RG requirements but was within the Characteristics RH limits. The deviation from Characteristic RG limits was of a minor nature, and occurred at temperatures above 25°C as shown in Figure 3.2.1-4.
3.2.1-5	N330 met Characteristic SH requirements.
3.2.1-6	N470 met Characteristic TH requirements.
3.2.1-7	N750 met Characteristic UJ requirements for temperature characteristics, but exceeded the maximum specified drift of 0.2 percent by 0.04 percent.

The following two characteristics are not included in MIL-C-20D, but are covered by EIA standard RS-198.

3.2.1-8	N1500 was within the ±250 ppm/°C envelope of EIA Std. RS-198; capacitance drift satisfied the 0.3 percent maximum specified.
3.2.1-9	N2200 was within the ±500 ppm/°C envelope of EIA Std. RS-198; one unit of the eleven tested exhibited capacitance drift exceeding the specified limit of 0.3 percent; the deviation was .01 percent.

Based on the above results, and other PEM efforts, Aerovox has demonstrated a capability of providing standard temperature characteristic performance of types NP0 to N2200 inclusive.

Bare Microelement Life-Tests

A summary of life test results obtained for bare elements of the extended-temperature-coefficient range types is shown in Table 3.2.1-3. These data represent over 1.8-million component hours of life testing under high temperature, high voltage stress conditions of 85°C and 100 dc volts. Evaluation of these life test results indicate the following:

a. Types N030, N080, N150, N220, N330, and N750 passed all specified requirements for the life test.

TABLE 3.2.1-3
SUMMARY OF AEROVOX LIFE-TEST DATA FOR EXTENDED-TEMPERATURE-COEFFICIENT RANGE MULTILAYER CAPACITORS AS BARE MICROELEMENTS
(Sheet 1 of 2)

CAPACITOR TYPE AND TEST PARAMETER	INITIAL VALUES	LIFE-TEST HOURS		
		250	1000	2000
N030: AVERAGE CAPACITANCE, 505 pf, 50 dc VOLTS				
Number on Test (b)	94	94	93	92
Number of Catastrophic Failures	-	0	0	0
Number of Degradational Failures	-	-	-	0
Average Capacitance Change - percent	-	-	-	0.02
Maximum Capacitance Change - percent	-	-	-	0.41
Maximum Dissipation Factor - percent	0.10	0.05	0.10	0.05
Minimum Insulation Resistance - megohms	>100 K	> 100 K	> 100 K	> 100 K
Accumulative Component-Hours	-	23,500	93,250	185,250
N080: AVERAGE CAPACITANCE, 592 pf, 50 dc VOLTS		314	1000	2000
Number on Test (b)	115	108	100	95
Number of Catastrophic Failures	-	0	0	0
Number of Degradational Failures	-	-	-	0
Average Capacitance Change - percent	-	-	-	.01
Maximum Capacitance Change - percent	-	-	-	.13
Maximum Dissipation Factor - percent	.07	.06	.05	.09
Minimum Insulation Resistance - megohms	28 K	> 100 K	> 100 K	> 100 K
Accumulative Component-Hours (c)	-	33,900	102,500	197,500
N150: AVERAGE CAPACITANCE, 452 pf, 50 dc VOLTS		250	1000	2000
Number on Test (b)	110	110	109	105
Number of Catastrophic Failures	-	0	0	0
Number of Degradational Failures	-	-	-	0
Average Capacitance Change - percent	-	-	-	.06
Maximum Capacitance Change - percent	-	-	-	.11
Maximum Dissipation Factor - percent	.06	.07	.07	.09
Minimum Insulation Resistance - megohms	>100 K	> 100 K	> 100 K	> 100 K
Accumulative Component-Hours (c)	-	27,500	109,250	214,250
		314	1000	2000
N220: AVERAGE CAPACITANCE, 496 pf, 50 dc VOLTS				
Number on Test (b)	117	117	114	108
Number of Catastrophic Failures	0	0	0	0
Number of Degradational Failures	-	-	-	0
Average Capacitance Change - percent	-	-	-	.07
Maximum Capacitance Change - percent	-	-	-	.51
Maximum Dissipation Factor - percent	.07	.06	.07	.08
Minimum Insulation Resistance - megohms	100 K	100 K	100 K	100 K
Accumulative Component-Hours (c)	-	36,700	114,900	222,900
N330: AVERAGE CAPACITANCE, 575 pf, 50 dc VOLTS		314	1000	2000
Number on Test (b)	125	125	116	110
Number of Catastrophic Failures	0	0	0	0
Number of Degradational Failures	-	-	-	0
Average Capacitance Change - percent	-	-	-	.06
Maximum Capacitance Change - percent	-	-	-	.17
Maximum Dissipation Factor - percent	.09	.07	.06	.07
Minimum Insulation Resistance - megohms	11.5 K	3 K	45 K	50 K
Accumulative Component-Hours (c)	-	39,300	108,800	218,800
N470: AVERAGE CAPACITANCE, 717 pf, 50 dc VOLTS		250	1000	2000
Number on Test (b)	95	95	95	83
Number of Catastrophic Failures	0	0	0	0
Number of Degradational Failures	-	-	-	2 (d)
Average Capacitance Change - percent	-	-	-	.74
Maximum Capacitance Change - percent	-	-	-	6.40
Maximum Dissipation Factor - percent	.09	.06	.20	.09
Minimum Insulation Resistance - megohms	>100 K	30 K	26 K	11 K
Accumulative Component Hours (c)	-	23,750	95,000	178,000

MT-21

TABLE 3.2.1-3
SUMMARY OF AEROVOX LIFE-TEST DATA FOR EXTENDED-TEMPERATURE-COEFFICIENT RANGE MULTILAYER CAPACITORS AS BARE MICROELEMENTS
(Sheet 2 of 2)

CAPACITOR TYPE AND TEST PARAMETER	INITIAL VALUES	LIFE-TEST HOURS 250	1000	2000
N750: AVERAGE CAPACITANCE, 297 pf, 50 dc VOLTS				
Number on Test (b)	110	110	107	103
Number of Catastrophic Failures	0	0	0	0
Number of Degradational Failures	-	-	-	0
Average Capacitance Change - percent	-	-	-	.24
Maximum Capacitance Change - percent	-	-	-	.42
Maximum Dissipation Factor - percent	.10	.09	.09	.09
Minimum Insulation Resistance - megohms	50 K	> 100 K	> 100 K	60 K
Accumulative Component-Hours (c)	-	27,500	107,750	210,750
N1500: AVERAGE CAPACITANCE, 763 pf, 50 dc VOLTS		250	1000	2000
Number on Test (b)	86	86	84	74
Number of Catastrophic Failures	0	0	0	2 (e)
Number of Degradational Failures	-	-	-	7 (f)
Average Capacitance Change - percent	-	-	-	.7
Maximum Capacitance Change - percent	-	-	-	5.6
Maximum Dissipation Factor - percent	.08	.07	.08	.10
Minimum Insulation Resistance - megohms	>100 K	> 100 K	24 K	10 K
Accumulative Component-Hours (c)	-	21,500	84,500	156,500
N2200: AVERAGE CAPACITANCE, 1620 pf, 50 dc VOLTS		250	1000	2000
Number on Test (b)	124	124	124	116
Number of Catastrophic Failures	0	0	0	0
Number of Degradational Failures	-	-	-	1 (g)
Average Capacitance Change - percent	-	-	-	2.03
Maximum Capacitance Change - percent	-	-	-	4.91
Maximum Dissipation Factor - percent	.08	.07	.10	.10
Minimum Insulation Resistance - megohms	> 100 K	> 100 K	> 100 K	35 K
Accumulative Component-Hours (c)	-	28,500	124,000	240,000

Notes:

(a) Life testing performed at 85°C with an applied voltage of 100 dc volts which represents twice rated voltage. Test results for periods other than 2000 hours were not required. Partial data shown at the intermediate test points are for informational purposes only.

(b) Periodic test handling resulted in removal of some units because of capacitor lead breakage.

(c) Accumulative component-hours are based on number of elements completing life test for the period indicated. Units removed from test for the reason mentioned in Note (b) are not included in the number of component-hours beyond the time of removal from test.

(d) Two units exceeded maximum allowable capacitance change of 3%; capacitance changes were -4.42 and +6.40 percent. The former change in capacitance may be due to a loss of external electrode metalizing during ultrasonic cleaning prior to final measurement; the latter may be due to a human error in reading the initial value (50 pf bridge reading error).

(e) Two catastrophic failures occurred; one at 1841 hours with no apparent cause for failure and one at 1921 hours with visual evidence of a breakdown through a dielectric layer.

(f) The seven units had excessive capacitance changes after life test ranging from +3.03 to +5.63 percent. Five of these units did not exceed 3.52 percent capacitance change. The indication is that these readings may be due to measurement errors resulting from using a 1-kc bridge for some measurements and 1-mc bridge for others.

(g) One unit exhibited a 4.91 percent capacitance change after life test. This deviation may have been due to an improper initial measurement.

MT-21

b. Types N470, N1500, and N2200 exhibited excessive capacitance changes during the life test. These deviations are the result of improper test measurement techniques. Note: Test data for encapsulated elements will verify this contention.

c. Type N1500 exhibited two catastrophic failures. The subcontractor will retest another group of these capacitors to show compliance with all life-test requirements. Fabrication of these elements will be completed early in the next period; life testing will start immediately thereafter.

As was previously reported in the 18th Quarterly Report, 15 elements of each of the nine capacitor types were incorporated into 45 test modules by RCA and the modules were returned to Aerovox for 2000-hour life test. The life tests are in progress and are scheduled to be completed early in the next period; results will be reported in the next quarterly report.

Cornell-Dubilier Electronics Division of Federal Pacific Electric Co., Single Layer Ceramic Capacitors

Prior to this quarter, Cornell-Dubilier completed all of the required single-layer capacitor facilities. They also completed their preproduction program and were authorized to proceed with the pilot-run production phase.

Fabrication of pilot-production parts was initiated at the start of this reporting period and the acceptance-test program will follow. During this quarterly period, the subcontractor also completed fabrication of four of the six required lots and subjected them to the required acceptance-testing procedure; these tests are now in process. The two remaining lots were possibly degraded due to a malfunction of the subcontractor's ceramic firing kiln. Cornell-Dubilier rejected these two lots and remade the units.

The first of the four completed lots (general-purpose type) was subjected to Group-A tests. This initial test was witnessed by RCA and Signal Corps personnel, but all subsequent Group-A testing will be supervised by Signal Corps quality approval personnel only. After satisfactory completion of Group-A requirements, 120 bare elements from this lot were placed on life test in accordance with specified test procedure. Early in the life test, the following results were recorded:

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Cornell-Dubilier advised RCA of this high-failure rate, and requested permission to life test a second test group of 120 elements taken from the same pilot-production lot. These elements will be coated with the same material as that used for micro-module processing (DC-271 and Stycast 2651-40). Cornell-Dubilier based their request on evidence obtained from their own experience, and reports from independent

sources which indicated that some high-dielectric-constant ceramic materials were adversely affected by atmospheric contamination under the conditions of high temperature, voltage stress, and time. RCA requested that insulation resistance measurements be taken at 125°C and at 25°C on approximately 20 percent of the surviving elements of the first life-test group to determine the extent of degradation. The following is a summary of data on 25 elements provided by the subcontractor. It indicates that the high-temperature insulation resistance is borderline with respect to specified requirements:

Test Condition	Insulation Resistance (megohms)			
	Minimum	Average	Maximum	Specified Minimum
Pre-Life Test, 25°C	>50,000	>50,000	-	10,000
After 194 hrs. of life test measured at 125°C	500	5,322	40,000	500[a]
After 194 hrs. of life test measured at 25°C	>40,000	>50,000	-	3,000[a]

[a] Minimum values specified after 2,000 hr. life test.

The subcontractor was then informed to proceed with the additional life test as requested in order to provide information for final disposition of the general-purpose lot. This lot will continue on life test to determine the final test results. Cornell-Dubilier initiated the additional test during the latter part of this period; over 500 hours of life test were completed at the end of this quarterly period, with no failures reported.

In a subsequent action, Cornell-Dubilier requested that permission be granted to perform life testing of all general-purpose capacitors on coated elements. No deviation in the test procedure for precision, temperature-compensating ceramic materials was requested, since these types are not affected by atmospheric conditions. This request has been forwarded to the Signal Corps for approval.

One hundred and twenty samples of a second pilot-production lot of 600 precision, temperature-compensating units, which passed Group-A tests, completed approximately 1800 hours of life test at the end of this period. One failure occurred after 724 hours of test. The subcontractor's analysis indicated that this element had a hairline crack in the substrate which could have been caused by the pressure used in marking the element. Cornell-Dubilier indicated that corrective action has been taken to prevent a recurrence of this defect. Since one life test failure is permitted, this pilot-production lot was accepted.

Electrolytic Capacitors

As previously reported in the 18th Quarterly Report, Astron Corp. and Sprague Electric Co. were approved to establish PEM facilities for electrolytic capacitor microelements. Purchase orders were placed with both subcontractors.

Both manufacturers have started their programs, and the following progress has been made:

Astron Corporation — Necessary equipments, tools and fixtures were acquired and set up at the subcontractor's plant. After the facility was inspected by RCA and found to be satisfactory, authorization was granted to initiate fabrication of preproduction samples.

Astron submitted a test facility list to RCA for instruments and other equipment which will be used du ing the preproduction and subsequent pilot-run test programs. Signal Corps approval of this equipment has been requested.

Sprague Electric Company — Except for some special assembly and test fixtures, Sprague's facility consists of the equipment used during the Initial Program. As a result, RCA provided authorization to proceed with preproduction sample fabrication which was started by Sprague during the latter part of this period. Sprague also submitted a test facility list which was reviewed by RCA, S & MD and forwarded to Surf-Com for approval.

Centralab Division of Globe Union — Variable Ceramic Capacitors

Centralab completed all PEM facilities and preproduction test samples. It has also started preproduction testing.

During this quarterly period, Centralab completed all preproduction testing except for life tests on encapsulated elements. Summaries of the preliminary preproduction test results are given in Table 3.2.1-4. An evaluation of this test data follows:

1. One-hundred seventy-one out of 225 capacitors subjected to visual and mechanical tests were acceptable, 54 units did not meet specifications. Centralab indicated the difficulty lay in the transfer of production from the development stage to the production stage. Most of the rejected elements failed because of mechanical defects.

2. Of the 171 units tested for initial electrical parameter, 32 were noted as having quality factors (Q) less than the 1000 minimum specified -- however, only four units exhibited a Q less than 500. It should be noted, that under the analysis phase of the program the minimum Q requirement for variable ceramic capacitors was 500; this requirement is also specified in MIL-C-81A.

3. All nine samples subjected to the solderability test failed because of "leaching" of the silver metalization by the solder. The rapid loss of the silver metalization in the solder was brought about by the critically thin silver metalization which was adversely affected by the solder temperature and the immersion time.

TABLE 3.2.1-4
SUMMARY OF CENTRALAB'S PREPRODUCTION TEST RESULTS ON VARIABLE CERAMIC CAPACITORS

TEST DESCRIPTION	1.5 to 5 pf 100 dc VOLTS		3 to 10 pf 100 dc VOLTS		2 to 20 pf 50 dc VOLTS	
	NO. OF ELEMENTS TESTED	NO. OF ELEMENTS FAILED	NO. OF ELEMENTS TESTED	NO. OF ELEMENTS FAILED	NO. OF ELEMENTS TESTED	NO. OF ELEMENTS FAILED
GROUP I						
Adherence of the Metalization	3	0	3	0	3	0
Short-Term Life Test	81	0	64	0	80	0
Visual, Mechanical Dimensions	81	20 (a)	64	7 (a)	80	27 (a)
Initial Electrical	61	10 (b)	57	12 (c)	53	14 (d)
Torque	61	0	57	0	53	0
Temperature Coefficient & Drift	3	0	3	0	3	0
Solderability	3	3 (e)	3	3 (e)	3	3 (e)
GROUP II						
Effect of Module Processing	29	5 (f)	31	7 (f)	32	9 (f)
Shock	6	0	6	0	6	0
Vibration, Low Frequency	6	1 (g)	6	0	6	0
Temperature & Immersion Cycle	6	0	6	0	6	2 (h)
Moisture Resistance	6	0	6	1 (i)	6	1 (i)
Altitude	6	0	6	0	6	0
Vibration, High Frequency	6	6 (j)	6	6 (j)	6	0
GROUP III (Operating Life Tests for 2000 hours at 125°C)						
As elements	20	7 (k)	20	14 (l)	20	16 (m)
Encapsulated in Modules	6	(Incomplete)	6	(Incomplete)	6	(Incomplete)
GROUP IV						
Module Processing (Final Submission			49	0	50	7 (n)

(a) Mechanical defects; center rivet not properly soldered and/or sealed.

(b) Q less than 1000; only four units less than 500.

(c) Seven units exceeded maximum capacitance setting limit; seven units had a Q less than 1000 but none less than 500.

(d) Two units exceeded the maximum capacitance setting limit; one unit exceeded limit at minimum setting; 15 units had a Q less than 1000, but only one unit less than 500.

(e) Silver "leached" during solder dip.

(f) Unsatisfactory primarily because of mechanical defects indicated in (a)

(g) Q less than 500 but greater than 300.

(h) One unit shorted during dielectric strength test; one unit had an excessive capacitance change.

(i) Two units had a low IR (1500 megohms and shorted; the second unit was low in IR prior to this test).

(j) Excessive capacitance change due to measurement errors; degradation of components not evident.

(k) Six units had an excessive capacitance change; one unit had a Q less than 500.

(l) Thirteen units with excessive capacitance change; six units with a Q less than 500.

(m) Twelve units with excessive capacitance change; eight units with a Q less than 500; one open unit.

(n) Four units had cracked rotors and three failed during module processing.

MT-22

4. Of 92 elements incorporated in test modules for Group II tests, 71 were satisfactory. An evaluation of the cause for nonconformance of the remaining 21 units was also due to the transfer of production from the development stage to production.

5. Environmental tests performed on the encapsulated units resulted in nonconformance of four elements. One nonconformance was due to a low-quality factor (Q) after low frequency vibration; one element shorted and another element exhibited excessive capacitance change after temperature and immersion tests. The fourth failure was due to low insulation resistance after moisture resistance. Twelve nonconformances of excessive ΔC were noted during high-frequency vibration testing. However, these nonconformances were determined to be the result of measurement error and not element failures.

6. Life-test data for the 60 bare elements indicated 31 exhibited excessive capacitance changes and one unit became open circuited between the 1000 hours and 2000 hours. Fifteen units had quality factors (Q) lower than the specified minimum. These results will be compared with life-test data for encapsulated elements.

Centralab initiated corrective actions to improve the Group I test results discussed above. The subcontractor agreed to fabricate 50 3-to-10 pf and 50 2-to-20 pf micro-elements to demonstrate the corrective actions taken. These 100 units were delivered to RCA, Somerville for encapsulation. All of the elements except four of the 2-to-10 pf rating were satisfactory; these four units had cracked rotors. The acceptable units were encapsulated into test modules and returned to Centralab for life tests.

An engineering meeting has been scheduled with the subcontractor during the early part of the next quarter to review the preproduction test data; a final test report will also be submitted to RCA at that time. A review of the PEM specifications will also be completed in preparation for the pilot run phase.

Coors Porcelain - Metalized Substrates

As previously reported in the 18th Quarterly Report, Coors completed the metalizing and handling equipment for metalized substrates.

Three engineering meetings were held at Coors Porcelain during this quarter to evaluate the status of the metalizing facility. At the first meeting, the performance of the line was found to be erratic due to problems with the wafer carriers, transfer equipment, centrifuge stations, and orientation feeder. At the third meeting, a mechanical engineer from the RCA Equipment Engineering along with Coors Engineering personnel reviewed the facility to determine corrective actions for several critical areas. As a result, a program was developed for the design and installation of equipment to improve these functions. This effort was accomplished and installation of the corrective actions was completed during the latter part of this quarter. The refinement of the facility is in progress; the processing parts and timing sequences are being established.

The substrates being metalized during the Preproduction Phase are the standard end-wafer and a wafer with a .165-inch square hole for diode mounting. Several shipments of metalized substrates have been received by RCA and continuous improvement has been noted in the quality of the metalized pattern. However, since the majority of the substrates have deficiencies, a complete appraisal of the quality of the line product has not been made.

During the next quarterly period, refinement of the facility will continue. The 27,000 preproduction samples will be completed and a pilot run of 23,000 units will be initiated.

3.2.2 RESISTORS

Objectives and Status

Program Extension II PEM for resistors is directed toward solving basic process and production problems for the manufacture of microelement resistors and toward establishing sources of supply for a broad range of microelement resistors. The first phase, process analysis, is complete. Each of the nine contractors who participated in the analysis phase has submitted process-analysis reports. On the basis of these reports and vendor performance during the analysis phase, two subcontractors — CTS Corporation and Microlectron, Inc. — were selected for the production facilitation phase. Both of these subcontractors will produce cermet resistors.

The second phase, production facilitation, is underway at both subcontractors. During this phase, CTS and Microlectron will set up a pilot line to manufacture and test 100 preproduction and 2500 pilot-run cermet microelement resistors using the production techniques developed during the process-analysis phase.

Another objective of the PEM is to establish a capability for precision resistor microelements. This will be accomplished by mounting conventional subminiature resistors on substrate wafers.

3.2.2.1 PRECISION RESISTORS, PROGRAM EXTENSION II, PEM

Six-hundred type MF3C metal-film tubular resistors were ordered from the Electra Manufacturing Company for qualification testing by RCA. As many as three of these miniaturized resistors can be mounted on one wafer; the resulting microelement thickness is .070 inch. These resistors have temperature coefficients from 50 to 150 ppm/°C, ±1 percent resistance tolerance, and values from 30 to 100,000 ohms. They are rated for full-load operation up to 125°C.

Initial RCA performance tests of the MF3C resistors indicated a capability for micro-module use. Load-life tests were run on four small lots of precision resistors from three manufacturers. As shown by the tabulated data below, the Electra units performed well. In addition, the Electra resistors are available as stock items, and need no further processing for micro-module use.

RESISTOR TYPE	QUANTITY TESTED	RESISTANCE CHANGE (%) AT: (hours)							
		50	100	250	500	750	1000	1500	2000
IRC, Metal-Film, Tubular	15	0.150	0.285	0.448	0.762	0.296	0.332	0.562	0.643
IRC, Wire-Wound, Tubular	4	0.725	0.675	0.714	0.689	1.963	0.546	0.767	0.792
Aerovox, Wire-Wound, Bobbin-Type	4	0.013	0.016	0.071	0.009	0.032	0.055	0.043	0.009
Electra, Metal-Film, Tubular	12	0.007	0.006	0.004	0.004	0.005	0.010	0.005	0.008

Although the Aerovox resistor had satisfactory stability, it was not considered for the Micro-Module Program use because only one resistor could be mounted on a wafer. In addition, the Aerovox unit was not commercially available.

Wafers for mounting test samples were ordered and received. Parts will be mounted, and testing will be started early in the next quarter.

3.2.2.2 UTILITY RESISTORS

The Signal Corps approved a qualification test program for utility resistors manufactured by Paktron Division of Illinois Tool Works, and the tests are being made by RCA. The resistor is a carbon resin applied to a tape which is sensitive to heat and pressure. The conventional resistor is bonded to a flat steatite wafer similar to an enlarged microelement wafer. The wafer is heated prior to bonding, the tape is applied by a mechanically activated platen, and the unit is terminated to the fired-on silver metalization of the wafer.

The resistors in the microelement form will be tested against Characteristic C of RCA Specification A-8972063, Revision D, of 9 May, 1962, entitled "Detailed Requirements for a General-Purpose, Semi-Precision and Precision Microelement Resistor."

The Paktron qualification-test samples were built by hand-application of the resistance tape to micro-module wafers. Preliminary tests of these samples were made on equipment being set up for incoming inspection of Task 39 material. Measurements made on a Quan-Tech noise meter revealed a noise level above that permitted by the specifications in an excessive number of elements. Earlier prototype samples had averaged much lower than the maximum noise level allowed by the specification.

Paktron analysis of the noise problem revealed poor bonding between the resistance elements and the termination electrodes. Similar units made by machine application of the tape to standard sized wafers had low-noise levels equivalent to the prototype samples. The higher noise level of the later samples was attributed to the lower wafer-preheating temperatures required for hand application, resulting in poorer bonding of the tape at the terminations.

Paktron will design a tape-application fixture for applying the resistors to wafers and remake the qualification samples. The new samples will be completed early in the next quarter, when testing will be resumed.

3.2.2.3 QUALIFICATION TESTS OF ELECTRA MICROELEMENT RESISTORS

Electra submitted an unsolicited proposal for a cooperative qualification-test program for microelement resistors. They proposed to qualify these resistors to RCA Specification A-8972063, Revision D, Characteristic B. The proposal was submitted to the Signal Corps with recommendation for approval. The Signal Corps will reserve a decision on this proposal until later in the program.

The microelement resistors under consideration are deposited-metal-film types having values from 10 to 100,000 ohm and initial tolerances of ±1 and ±2 percent. Because these resistors are metal-film types, they are potentially capable of meeting the Characteristic A, precision requirements of the same specification.

3.2.2.4 SEMIPRECISION RESISTORS

Microlectron

Microlectron revised its preproduction report for review by RCA. It was submitted to the Signal Corps and approved. Pilot-run production was completed with the construction of 2500 microelements of four different part numbers. Group-A testing on a 100 percent basis was completed on these pilot-run parts. Only 1.4% of the parts were rejected for all causes. Most of these rejects were for visual and mechanical failures, such as cracked wafers.

The Group-B and Group-C test modules have been built and encapsulated by Microlectron and testing will be started early next quarter.

CTS Corporation

CTS preproduction testing is complete. The preproduction report, based on 1500 hours of load-life testing was written, and an addendum containing the 2000-hour data was prepared. At the end of 2000 hours, the maximum resistance change was 0.84 percent and this change occurred in a 47-ohm resistor element. Note: There were 232 resistor elements contained in 58 microelements. The specification permits a maximum change of ±2 percent. The only nonconformances were in the temperature-coefficient tests in Group-B testing, and were reported last quarter; these deviations were minor. The preproduction report was submitted to the Signal Corps with a request for approval. Pilot-run production will be started as soon as authorization is received.

3.2.3 INDUCTORS PROGRAM EXTENSION II, PEM

Objectives and Status

The analysis phase of the Production Engineering Measure for inductors under Program Extension II extends inductance and frequency capabilities beyond those achieved in the Initial Program. One subtask is devoted to providing an improved inductor-packaging method which will be compatible with the precision-header, dip-soldering technique of module assembly.

3.2.3.1 MICROELEMENT PULSE TRANSFORMERS

Previously, Aladdin's life-test program on pulse transformers disclosed insulation-resistance problems. As a result, the pulse transformer was redesigned and 100 additional final-grade samples were fabricated and resubmitted to life test.

Final-grade pulse transformers, Aladdin Type 01-717, were constructed with an improved wire and core insulating system. These improvements were the result of investigating several types of wire insulation, interwinding insulating tapes, and core insulation materials. The PERT chart in Figure 3.2.3-1 describes in detail the parallel approaches investigated.

One hundred and twelve encapsulated samples were selected for Group-B and Group-C tests. These units were obtained from the following production at Aladdin:

212	starts at Aladdin
- 84	rejects as noted below
128	encapsulated at RCA
- 16	spares
112	selected for Group-B and -C tests

The 84 rejects consisted of the following:

39	rejected at winding
24	rejected at inductance test
2	rejected in assembly and soldering
5	rejected at insulation resistance test
14	rejected for mechanical reasons
84	

The manufacturing system for the final-grade 01-717 units consisted of No. 45 heavy-polyurethane insulated wire wound on a ferrite bobbin which was insulated with a coat of Glyptal. These units were not impregnated because the evaluation of the steps shown in the PERT chart did not indicate any appreciable improvement in insulation resistance after impregnation.

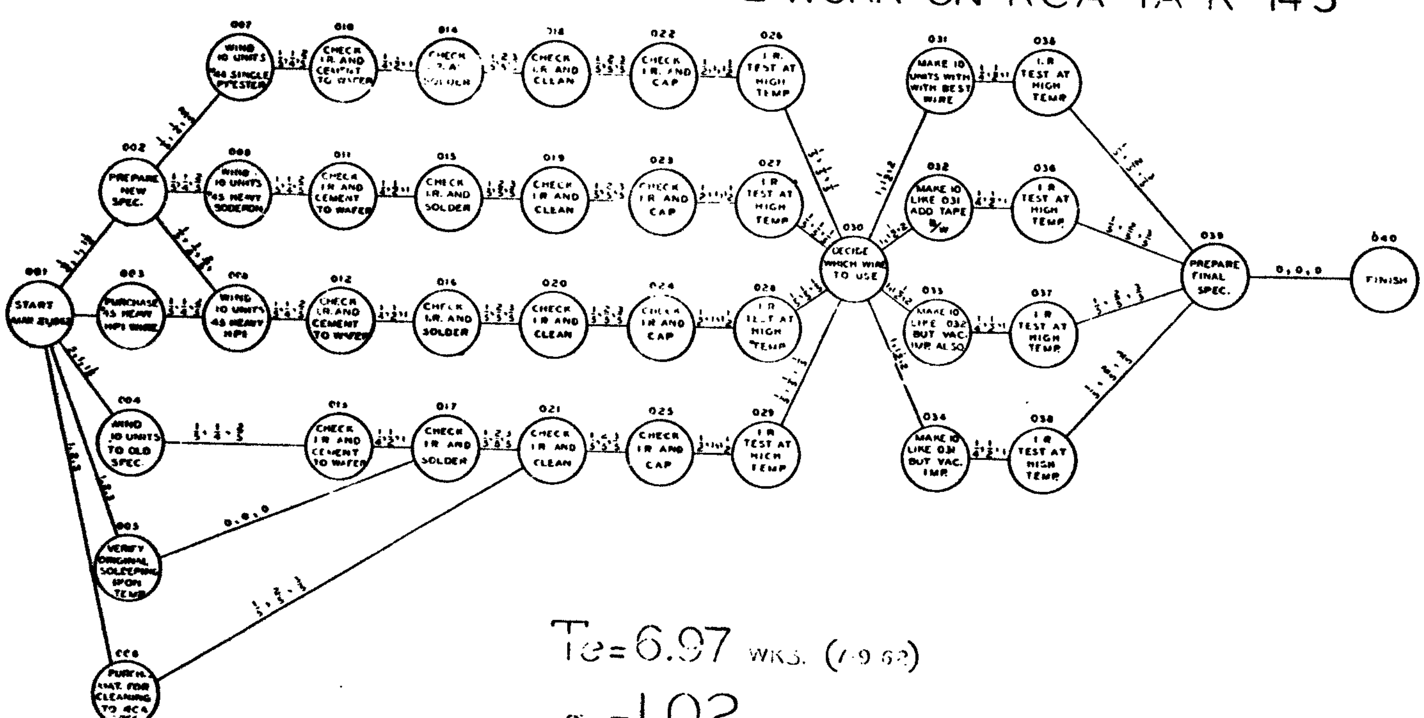
Deep substrates supplied by Molecular Dielectrics were used on all final-grade units. Leads were soldered in the radial grooves with low-temperature solder and capped with Stycast 2651-40 epoxy. This substrate is described and illustrated in Figure 3.2.3-1 of the 18th Quarterly Report.

Group-B Tests

The results of environmental tests on final-grade 01-717 pulse-transformers are summarized in Tables 3.2.3-1 and 3.2.3-2. Twelve units were selected after encapsulation and Group-A tested. These units exhibited good performance during static and dynamic tests.

Interwinding capacitance was slightly higher than the Aladdin specification of 30 pf maximum, but this higher capacitance value is attributed to encapsulation. This

PERT DIAGRAM FOR EXPERIMENTAL WORK ON RCA TASK 14-3



$T_e = 6.97$ WKS. (7-9-62)

$\sigma = 1.02$ WKS.

Figure 3.2.3-1. Pert Chart for Improved Insulation Tests on Aladdin Final-Grade Pulse Transformers

TABLE 3.2.3-1
SUMMARY OF GROUP-B STATIC TESTS ON ALADDIN TYPE 01-717 FINAL-GRADE PULSE TRANSFORMERS

DESCRIPTION	VALUE	PRIMARY INDUCTANCE (μh)	LEAKAGE INDUCTANCE (μh)	CAPACITANCE PRI/SEC (pf)	CAPACITANCE DISTRIBUTED (pf)	RESISTANCE PRI (ohms)	RESISTANCE SEC (ohms)	INSULATION RESISTANCE PRI/SEC (10^3 megΩ)	DIELECTRIC STRENGTH (100rms-v)
Aladdin Specification for Type 01-717	Nom Max Min	130 143 117	- 3.0 -	- 30.0 -	- 10.0 -	- 3.0 -	- 38 -	- - 10[c]	- - 100
Test Results on 12 Group-B Samples after Encapsulation[a]	Avg Max Min	130. 140. 120.	1.62 1.80 1.42	28.7 34.0 22.0	5.6 5.9 4.9	2.56 2.63 2.49	33.5 34.2 32.8	400 400 170	OK
Test Results on 12 Group-B Samples after Shock, Vibration, and Immersion[b]	Avg Max Min	128 139. 118.	1.79 1.96 1.62	29.0 35.5 21.5	5.3 5.8 4.7	2.54 2.64 2.46	33.3 34.1 32.7	390 400 300	OK
Test Results on 12 Group-B Samples after Moisture Resistance	Avg Max Min	130 138. 120.	1.70 1.80 1.50	30.0 37.0 22.0	5.6 5.9 5.3	2.52 2.62 2.47	33.6 34.2 33.1	113 210 16	OK

MT-23

(a) All test measurements made by Aladdin
(b) High Frequency vibration test results not included.
(c) RCA Specification: 10^3 megohms minimum.

TABLE 3.2.3-2
SUMMARY OF GROUP-B DYNAMIC TESTS ON ALADDIN TYPE 01-717 FINAL-GRADE PULSE TRANSFORMERS

DESCRIPTION	VALUE	OUTPUT (p-p volts) SEC 1	OUTPUT SEC 2	RISE TIME (μ sec) SEC 1	RISE TIME SEC 2	FALL TIME (μ sec) SEC 1	FALL TIME SEC 2	OVERSHOOT (%)	DROOP (volts) SEC 1	DROOP SEC 2	BACK SWING (volts) SEC 1	BACK SWING SEC 2	RECOVERY (μ sec) SEC 1	RECOVERY SEC 2
Aladdin Specification For Type 01-717	Nom Max Min	- 1.05 .95		- 0.15 -		- 0.15 -		- 15 -	- 0.22 -		- 0.25 -		- 10 -	
Test Results on 12 Group-B Samples After Encapsulation[a]	Avg Max Min	1.0 1.0 1.0	1.0 1.0 1.0	.066 .07 .065	.12 .12 .10	.052 .052 .052	.06 .072 .05	2 3 1	.20 .21 .19	.18 .19 .17	.25 .25 .23	.21 .22 .19	3.4 3.5 3.2	3.4 3.5 3.2
Test Results on 12 Group-B Samples After Shock, Vibration, and Immersion[b]	Avg Max Min	1.0 1.0 1.0	1.0 1.0 1.0	.065 .070 .075	.12 .13 .11	.052 .052 .052	.056 .060 .048	2.3 3 2	.194 .20 .19	.18 .19 .17	.24 .26 .23	.21 .22 .20	3.4 3.5 3.2	3.4 3.5 3.2
Test Results on 12 Group-B Samples After Moisture Resistance	Avg Max Min	1.0 1.0 1.0	1.0 1.0 1.0	.070 .080 .060	.12 .13 .10	.052 .056 .044	.054 .060 .048	3.0 4 2	.195 .20 .18	.18 .20 .15	.25 .25 .23	.21 .23 .20	3.7 4.5 3.5	3.6 3.8 3.0

MT-24

(a) All test Measurements made by Aladdin.
(b) High-Frequency-Vibration Test Results not included.

parameter increased approximately 4 percent following shock, vibration, immersion, and an additional 4 percent following moisture resistance. Following these tests, the increase in interwinding capacitance had no measurable effect on the dynamic performance of the pulse transformers. Therefore, these changes are not considered significant.

Insulation resistance values were generally unchanged following shock, vibration, and immersion tests. After moisture-resistance tests some reduction in insulation resistance was observed. However, the lowest value of 1.6 x 10^4 megohms still exceeded the specified minimum of 10^4 megohms.

The dynamic performance was satisfactory following all environmental tests. Minor increases in overshoot were observed following moisture resistance, but these variations were still within specified limits. Back-swing values increased 4 percent following shock, vibration and immersion tests, but did not degrade following moisture-resistance tests.

The temperature performance of the primary inductance on five of the 12 encapsulated samples is indicated in Figure 3.2.3-2. Variation between units was approximately 3 percent; all units were within the specified ±12 percent inductance stability from -30°C to +100°C.

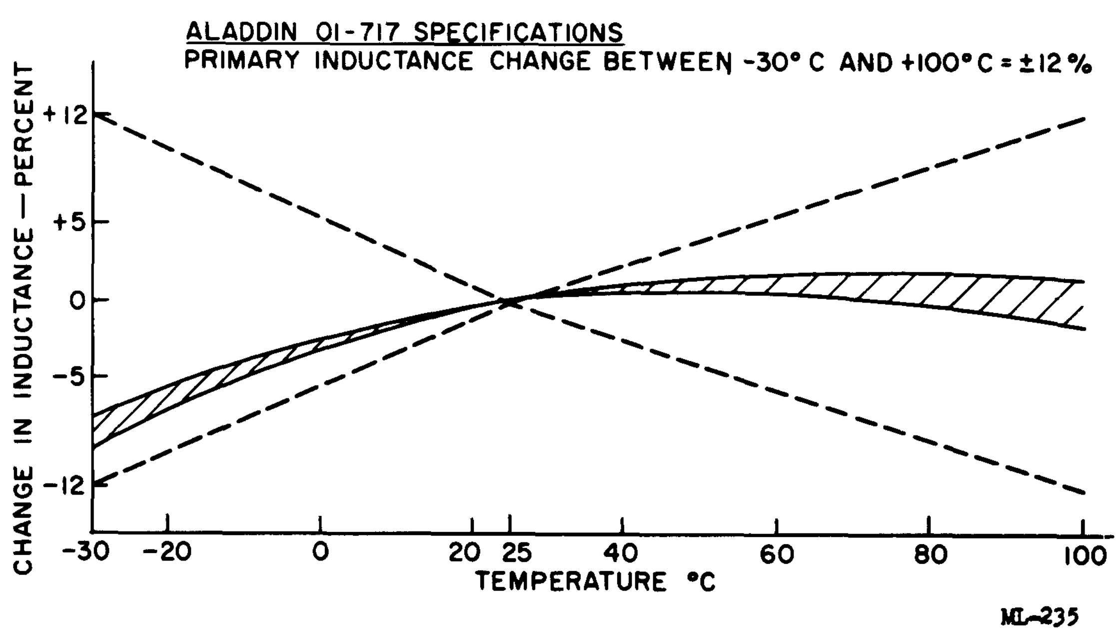


Figure 3.2.3-2. Temperature Performance of Five Encapsulated Aladdin Type 01-717 Pulse Transformers

The 12 Group-B test units completed all tests except high-frequency vibration. Aladdin has delivered these 12 units and an additional 6 units to RCA for the high-frequency-vibration test. The test results will be reported next quarter.

Group-C Tests

One-hundred final-grade 01-717 pulse transformers were manufactured by Aladdin and delivered to RCA, Somerville, for encapsulation. Tables 3.2.3-3 and 3.2.3-4 summarize the Group-C test results on these units after encapsulation. Interwinding capacitance exceeded the Aladdin specification of 30 pf maximum as a result of encapsulation. Two additional units are being tested at RCA to evaluate these changes after encapsulation. Results will be reported next quarter.

These encapsulated units were arranged in a series-parallel arrangement as indicated in Figures 3.2.3-3 and 3.2.3-4. Operating potentials applied during the Group-C test at 100°C include an input pulse, secondary bias current, and an interwinding potential of +30 dc volts. All potentials were monitored during the test for any degradation occurring at any time during the 2000 hour period.

After approximately 1200 hours, all units were removed from the life-test oven and subjected to Group-A tests. All units passed the dynamic and static tests except for two units that shorted when subjected to the 100 rms-volt dielectric strength test. These units did not short with 30 dc volts applied between windings while on the life-test board.

All 100 units had an insulation resistance in excess of 10^5 megohms prior to the start of the life test, and 98 of the 100 units had an insulation resistance greater than 2×10^5 megohms after 1200 hours. The two shorted units had insulation resistance values of 350 ohms and 17 ohms between windings when measured with a low-voltage ohmmeter. The RCA specification for minimum insulation resistance is 1000 megohms. These units are being analyzed by Aladdin; failure-mechanism details will be reported next quarter.

The remaining 98 units were returned to life test and completed 2000 hours. Complete Group-C test data will be reported in the next quarterly report.

3.2.3.2 DELEVAN ELECTRONICS - ADJUSTABLE LOW-FREQUENCY REACTOR MICRO-MODULES

Delevan submitted the required 50 final samples along with life-test data and a final report.

TABLE 3.2.3-3
SUMMARY OF GROUP-C STATIC TESTS ON ALADDIN TYPE 01-717 FINAL-GRADE PULSE TRANSFORMERS

DESCRIPTION	VALUE	INDUCTANCE PRI (μh)	INDUCTANCE LEAK (μh)	CAPACITANCE PRI/SEC (pf)	CAPACITANCE DIST. (pf)	RESISTANCE PRI (ohms)	RESISTANCE SEC (ohms)	INSULATION RESISTANCE PRI/SEC (10^3 megohms)	DIELECTRIC STRENGTH (100 v rms)
Aladdin Specification For Type 01-717	Nom	130	-	-	-	-	-	-	-
	Max	143	3.0	30.0	10.0	3.0	38	-	-
	Min	117	-	-	-	-	-	10[c]	100
Test Results Before Encapsulation on 128 Samples[a]	Avg	128.	-	-	-	-	-	OK	OK
	Max	143.	-	-	-	-	-		
	Min	117.	-	-	-	-	-		
Test Results After Encapsulation on 100 Group-C Samples	Avg	128.	1.62	32.0	5.6	2.50	33.0	400	OK
	Max	142.	1.85	38.0	6.9	2.66	34.6	400	
	Min	119.	1.40	22.0	4.9	2.43	31.4	100	
Test Results After 1200 Hours at 100°C on 100 Group-C Samples[b]	Avg Max Min	OK		OK		OK		98 Samples > 200 2 Failed	98 OK 2 Failed

MT-25

(a) All test measurements made by Aladdin.
(b) Two units failed dielectric strength test during Group-A tests at 100 rms volts.
(c) These units were good prior to Group-A testing while on life test with 30 volts between windings.
RCA Specifications = 10^3 megohms minimum.

TABLE 3.2.3-4
SUMMARY OF GROUP-C DYNAMIC TESTS ON ALADDIN TYPE 01-717 FINAL-GRADE PULSE TRANSFORMERS

DESCRIPTION	VALUE	OUTPUT (p-p volts) SEC 1	OUTPUT (p-p volts) SEC 2	RISE TIME (μ sec) SEC 1	RISE TIME (μ sec) SEC 2	FALL TIME (μ sec) SEC 1	FALL TIME (μ sec) SEC 2	OVER-SHOOT (%)	DROOP (volts) SEC 1	DROOP (volts) SEC 2	BACK SWING (volts) SEC 1	BACK SWING (volts) SEC 2	RECOVERY (μ sec) SEC 1	RECOVERY (μ sec) SEC 2
Aladdin Specification for Type 01-717	Nom	-		-		-		-	-		-		-	
	Max	1.05		0.15		0.15		15	0.22		0.25		10	
	Min	.95		-		-		-	-		-		-	
Test Results Before Encapsulation on 128 Samples[a]	Avg Max Min	OK		OK		OK		OK	OK		OK		OK	
Test Results After Encapsulation on 100 Group-C Samples	Avg	1.0	1.00	.065	.11	.056	.059	2.7	.19	.18	.25	.21	3.4	3.4
	Max	1.0	1.0	.070	.13	.056	.072	5.	.21	.19	.25	.23	3.5	3.5
	Min	1.0	1.0	.060	.10	.048	.044	1.	.17	.16	.23	.20	3.0	3.0
Test Results After 1200 Hours at 100°C on 100 Group-C Samples[b]	Avg Max Min	OK		OK		OK		OK	OK		OK		OK	

MT-26

(a) All test measurements made by Aladdin.
(b) Includes 2 samples that failed dielectric strength between windings.

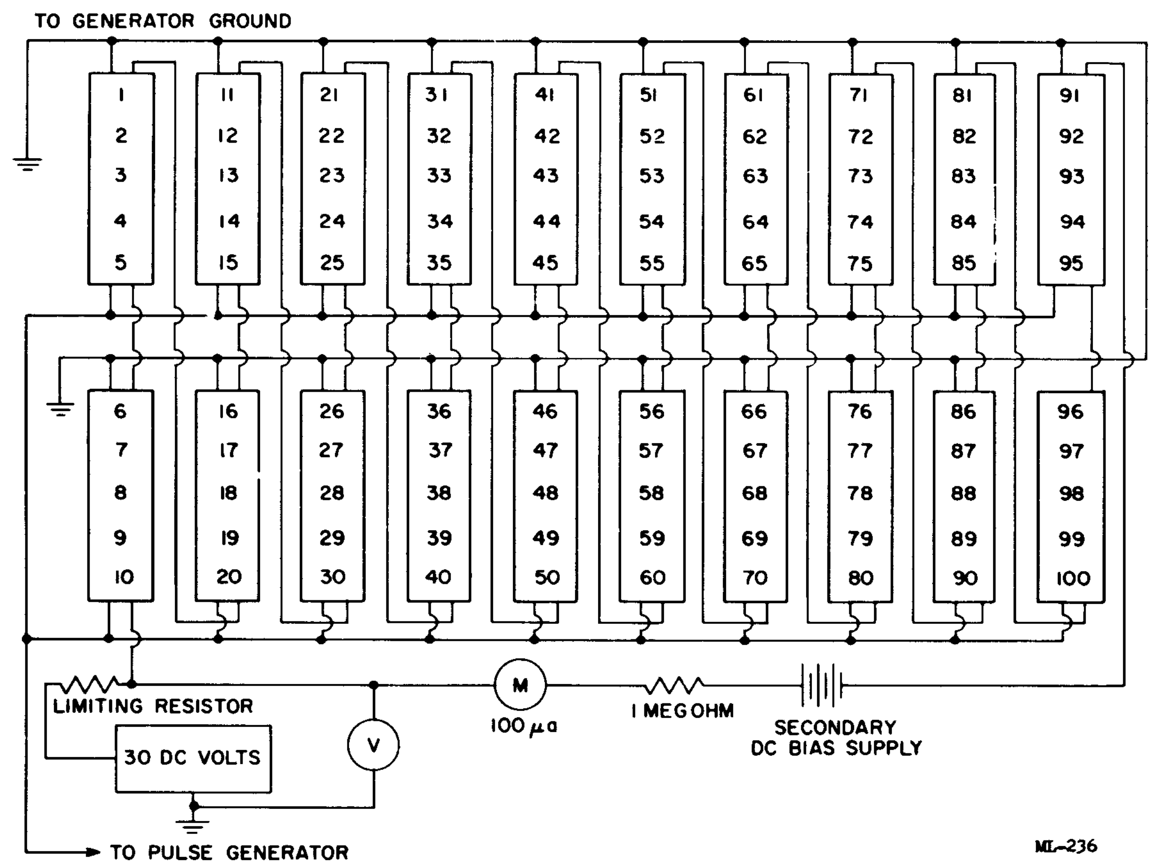


Figure 3.2.3-3. Series-Parallel Arrangement for Group-C Life Tests on 100 Pulse Transformers

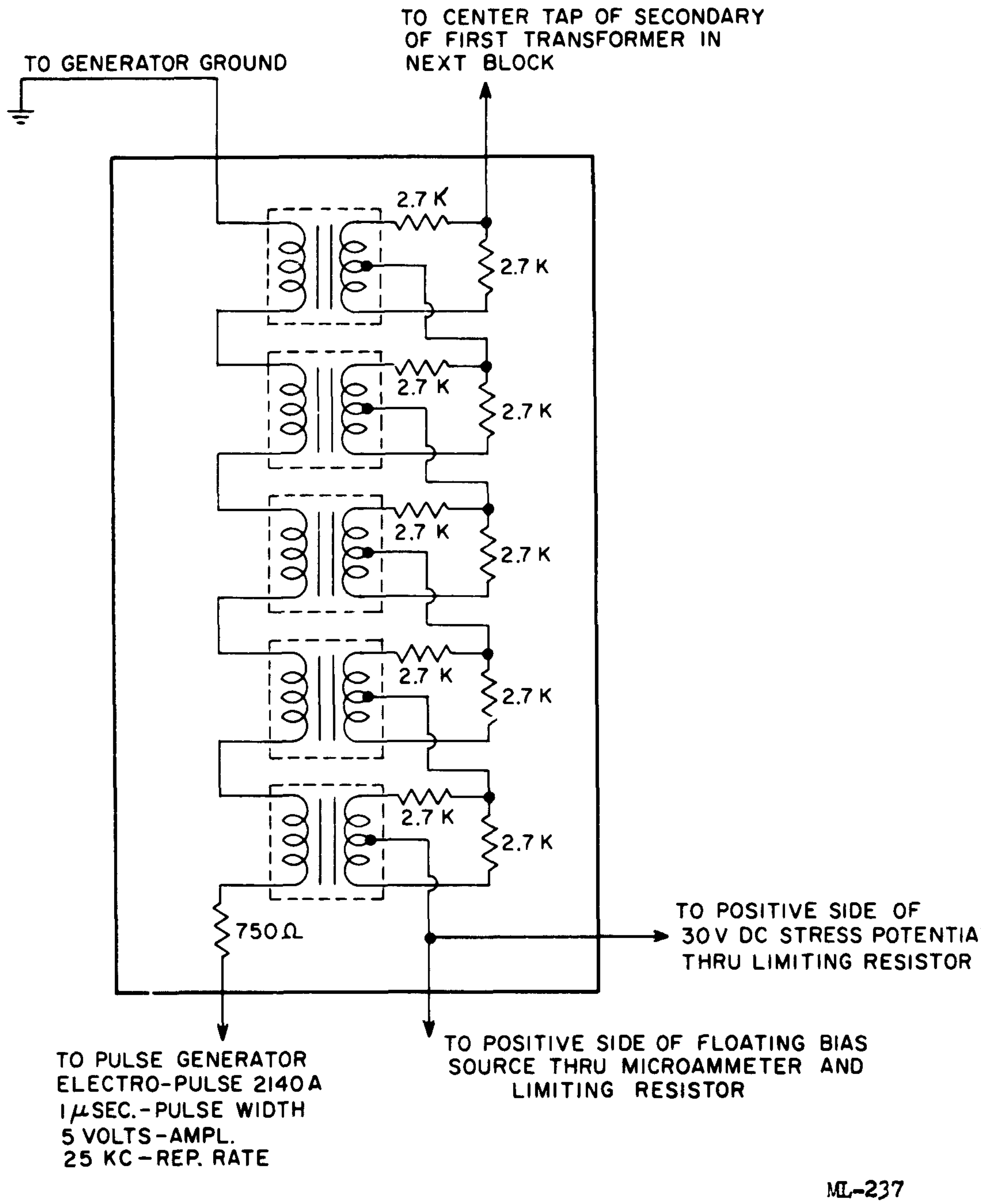


Figure 3.2.3-4. Detailed Schematic of One Series Arrangement of the 20 Branches Shown in Figure 3.2.3-3

The life test set up is shown in Figure 3.2.3-5. Tests were performed in accordance with RCA Specification 2025982. The life-test summary is shown in Table 3.2.3-5. An analysis of the life test data is given in the following summary:

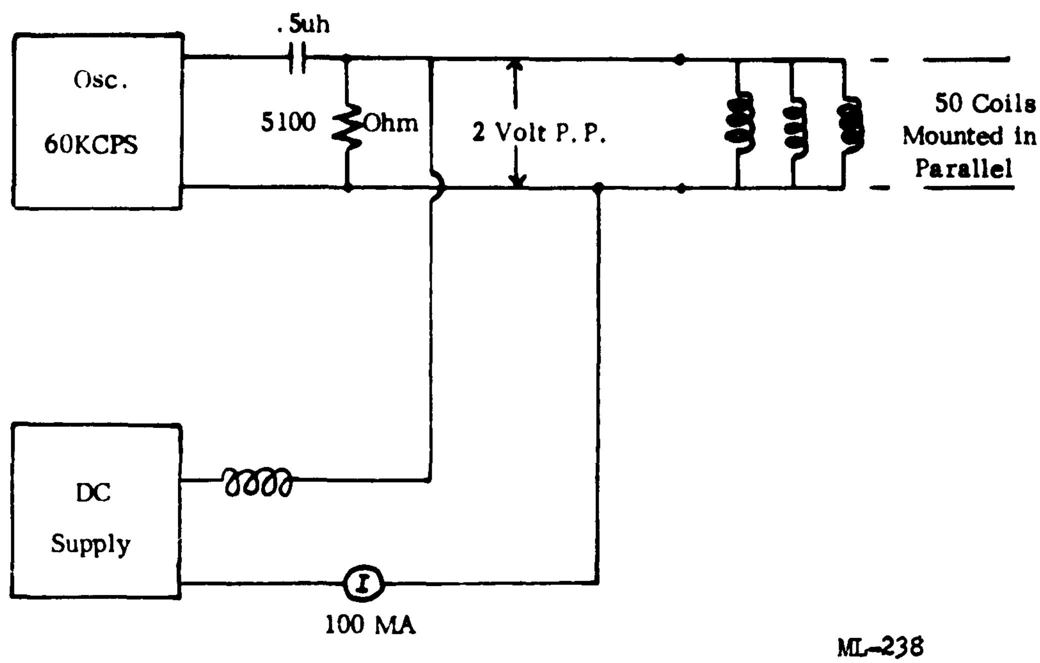
Delevan Test Number	
A-1	Seven of the 50 units tested exceeded the maximum width of 0.365 inch. However, these units were oversize prior to testing, and are not considered life-test failures.
A-3	The average of all inductance values indicated a decrease of 4.4 percent in the effective magnetic permeability following the life test.
A-4	Four units did not meet the Q limits of 59 to 69, which represent the specified tolerance of ±8 percent of the Q value of the standard nominal inductance. One value was below Q = 59, and three of the values were above Q = 69. However, all of the values remained above the minimum Q of 45. The average of all the Q values showed an increase of 11.5 percent as a result of life testing.
A-7	One unit was below the minimum self-resonant frequency of 415 kc established from the standard. The value was found to be 370 kc. This lower frequency could not be accounted for, and the unit was considered a failure. The average of all the self resonant values showed an increase of 10.8 percent.
A-8	One unit had a drive sensitivity of less than 0.5 ppm/mv which represents 50 percent of the drive sensitivity of the standard unit.
A-11	The average of all the dc resistance values indicated an increase of 0.4 percent in copper conductivity after the life test.

Group-B Tests

Group-B tests were performed in accordance with RCA Specification 2025982. A group of nine samples submitted to Group-B tests failed because of changes in inductance and Q after high-temperature, vibration, shock, immersion, and moisture-resistance tests. These nine test samples were divided into one group of six and another group of three.

Spec: RCA 2025982

"C" Test (Accelerated Life) Conditions



Time and Date Concluded: 11:00 AM 9/26/62

Time and Date Initiated: 11:00 AM 7/3/62

Test Time = 2040 Hours

Figure 3.2.3-5. Life Test Arrangements for Delevan Low Frequency Inductors

TABLE 3.2.3-5
SUMMARY OF LIFE TEST ON DELEVAN LOW-FREQUENCY INDUCTORS

(Specification: RCA 2025982; "C" Tests ("A" Test After Accelerated Life))

TEST NUMBER	TEST TITLE	REQUIREMENT	NUMBER TESTED	NUMBER FAILED	MAX	MIN	AVERAGE
A-1	Visual and Mechanical	RCA 2016902 RCA 492855-35	50 50	10, Torque 7 for width	.3673	.360	.3619
A-2	Dielectric Strength	MIL-C-15305B 100 VRMS	50	0	--	--	--
A-3	Trim Range	L Nom ±8% min	50	8	--	--	--
A-4	Q at L Nom	±8% of std.	50	6	65	49	58
A-5	Mid Ind.	Discontinued					
A-6	Q Variation with L	Less than |.75| % Q/% L	50	0	.256	0	--
A-7	Self-Resonance	±25% of std. at L Nom	50	1	690	370	585
A-8	Drive Sensitivity	±50% of std. PPM L/MV	9	3	1.5	.32	1.07
A-9	Bias Sensitivity	±15% of std. PPM L/MA	9	0	1.050	.980	1.026
A-10	Insulation Resistance	MIL-C-15305B 100 Megohms	50	0	--	--	--
A-11	DC Resistance	±10% of std. (48.7 ohms)	50	0	50.0 ohms	48.58 ohms	49.4 ohms

MT-27

The inductance change of the group of six samples after subjection to high-temperature tests was -3 percent; the specification is ±2 percent. However, this variation is characteristic of this construction. Inductance changes after vibration and shock were the result of not cementing the cores in position before these tests were made.

The large change in Q after immersion and moisture-resistance tests was caused by moisture leakage to the windings.

Two of the group of three units tested for temperature coefficient were found to be outside the T. C. tolerance limits. However, all three units exhibited T. C.'s lower than the specified 220 ppm/°C.

A group of six samples with improved trim-sealing was resubmitted to Group-B test to replace the above group of six samples that failed high temperature and moisture tests. The trim-seal material was Dow Corning Sylgard 183. This material has low-moisture absorption, temperature stability, low viscosity, and also acts as a moisture barrier. The six resubmitted units passed all tests with the exception of moisture resistance; moisture tests reduced the Q in five samples beyond the five-percent degradation allowed. Two of three samples tested still exceeded the tolerance for temperature coefficient. Summaries of the original and resubmitted Group-B results are given in Tables 3.2.3-6 and 3.2.3-7.

3.2.3.3 COLLINS RADIO — MEDIUM-FREQUENCY FIXED-INDUCTOR MICRO-ELEMENT

This task involves the construction of range, prototype, and final-grade samples for medium-frequency fixed inductor microelements. Approval was obtained for Collins to proceed with the fabrication of the 20 required prototypes.

Collins has submitted 17 of the required 20 prototype samples. The quantity was limited by a shortage of cores. The prototype samples were 455-kc i-f transformers designed to meet the requirements of RCA Purchase Drawing A-2016903.

Materials — The ceramic substrates were supplied by Coors Porcelain in accordance with the Collins Drawing 495-9500-200. Some substrates were metalized by Ceramics International and the terminal-spider preform was brazed by Collins; and other substrates were metalized and brazed by Coors Porcelain.

Ferrite Cores were supplied by Indiana General in accordance with Collins Drawings 490-4704-500/508 and 490-7404-401/403. The wire used was Rea Heavy Solvar AWG 41. The casting material used was Dow Corning Sylgard. The winding form and the outer wrap were made from Minnesota Mining and Manufacturing No. 56 tape.

Process — The primary was wound randomly on the winding tube with a total of 134 turns and tapped at 48 turns. The secondary was wound directly over the primary with 11 turns. The coil was installed in the cup-core and held with nonmagnetic, nonconductive clips. The unit was adjusted to the proper inductance by rotating the core lid in respect to the core body. Then the coil was secured with Eastman No. 910

TABLE 3.2.3-6
SUMMARY OF GROUP-B TEST RESULTS ON DELEVAN LOW-FREQUENCY INDUCTORS
(Sheet 1 of 2)
(Specification: RCA 2025982;"B" Tests (MIL-C-15305B, Class O))

Test Number	Test Title	Requirement	MIL-C-15305 Test	Number Tested	Number Failed
B-1	Visual and Mechanical	RCA 492855-35 Revision 5	4.7.1.1	9	0
B-2	Inductance L Nom	±2% of standard	----	9	0
B-3	Q	±5% of standard	----	9	0
B-4	Dielectric Strength	100 VRMS Para. 3.7	4.7.3	9	0
B-5	Insulation Resistance	100 VDC Para. 3.9	4.7.5	9	0
B-11	Temperature Coefficient -10 to +85 °C	Method defined D. E. I. #42	----	3	2
B-12	Overload	MIL-C-15305B Para. 3.12	4.7.8	3	0
B-13	Terminal Strength	MIL-C-15305B Para. 3.13	4.7.9	3	0
B-14	Effect of Soldering	MIL-C-15305B Para. 3.14	4.7.10	3	0
B-15	High Temperature	MIL-C-15305B Para. 3.15	4.7.11	3	0
B-16	Inductance	±2% of B-2	----	3	3
B-17	Q	±5% of B-3	----	3	0

TABLE 3.2.3-6
SUMMARY OF GROUP-B TEST RESULTS ON DELEVAN LOW-FREQUENCY INDUCTORS
(Sheet 2 of 2)
(Specification: RCA 2025982; "B" Tests (MIL-C-15305B, Class O))

Test Number	Test Title	Requirement	MIL-C-15305 Test	Number Tested	Number Failed
B-18	Visual and Mechanical	RCA 492855-35 Rev. 5	4.7.1.2	1	0
B-22	Vibration	MIL-C-15305 Para. 3.16	4.7.12.2	6	-
B-23	Inductance	±.5% of B-2	----	6	3
B-24	Shock	MIL-C-15305B Para. 3.17	4.7.13	6	-
B-25	Inductance	±.5% of B-2	----	6	3
B-26	Temperature Cycling	MIL-C-15305B Para. 3.18	4.7.14	6	-
B-27	Immersion	MIL-C-15305B Para. 3.19	4.7.15	6	-
B-28	Q	±5% of B-3	----	6	4
B-29	Insulation Resistance	MIL-C-15305B Para. 3.9	4.7.5	6	0
B-30	Moisture Resistance	MIL-C-15305B Para. 3.20	4.6.16	6	-
B-31	Q	±5% of B-3	----	6	5
B-32	Insulation Resistance	MIL-C-15305B Para. 3.9	4.7.5	6	0

TABLE 3.2.3-7
RETEST OF GROUP-B TESTS ON DELEVAN
LOW-FREQUENCY INDUCTORS
(Specification: RCA 2025982; "B" Retest (MIL-C-15305B, Class O))

Test Number	Test	Requirement	MIL-C-15305 Test	Number Tested	Number Failed
B-2	Inductance L Nom	±2% of standard	----	6	0
B-3	Q	±5% of standard		6	0
B-4	Dielectric Strength	100 VRMS Para. 3.7	4.7.3	6	0
B-5	Insulation Resistance	100 V DC Para. 3.9	4.7.5	6	0
B-11	Temp. Coefficient -10 to +85°C	Method defined DEI #42	----	3	2
B-27	Immersion	MIL-C-15305B Para. 3.19	4.7.15	6	-
B-28	Q	±5% of B-3	----	6	0
B-29	Insulation Resistance	MIL-C-15305B Para. 3.9	4.7.5	6	0
B-30	Moisture Resistance	MIL-C-15305B Para. 3.20	4.7.16	6	-
B-31	Q	±5% of B-3	----	6	6
B-32	Insulation Resistance	MIL-C-15305B Para. 3.9	4.7.5	6	2

cement. The transformer was mounted into the substrate and secured by the same material. After the leads were placed at the proper lug locations, the lugs were crimped as shown in Figure 3.2.3-6. The connections were then soldered, and the lugs were trimmed and bent flush. The units were then adjusted to the proper inductance, inspected, and encapsulated with Dow Corning Sylgard. After a three hour cure at 120°C the units were placed on a Mylar surface, with lugs down, and the surface was sealed.

The 17 units were received by RCA, Somerville and inspected for visual and mechanical properties, inductance, and Q. Defects in the following areas were noted:

Mechanical dimensions	Spider-preform alignment
Solder or metalizing spots	Casting
Solder coating	Cracked cores
Land dimensions	Q deviations

Because of the above deficiencies, 17 prototype samples were rejected and will be resubmitted. Collins is now in the process of procuring improved materials from Coors Porcelain and Indiana General. Coors made revisions of the tooling for its substrate wafers and submitted wafer samples which show marked improvements in squareness and physical dimensions.

Mechanical Dimensions

Testing on a pin gauge showed that the notch dimensions of some of the new wafers were marginal. Two of 12 metalized wafers delivered to Collins exceeded the maximum over-all dimension of 0.314 inch. The notch width of the unmetalized wafers approached the lower tolerance limit. This requires caution in the metalizing and tinning processes to avoid excessive build-up which would not pass the pin gauge test.

Cracked Cores

Sufficient crack-free ferrite cores were received from Indiana General. However, Indiana General could eliminate cracks only by omitting the surface profile of the core center post required for trim adjustment. The center post profile is now applied by a separate grinding process.

The casting problems encountered on prototype units pre-encapsulated with Sylgard will be eliminated by using a vacuum encapsulation process.

As a back up, Collins has received 30 ferrite core samples from Ferroxcube. These cores appear to be denser and stronger. Although they have slightly less winding space

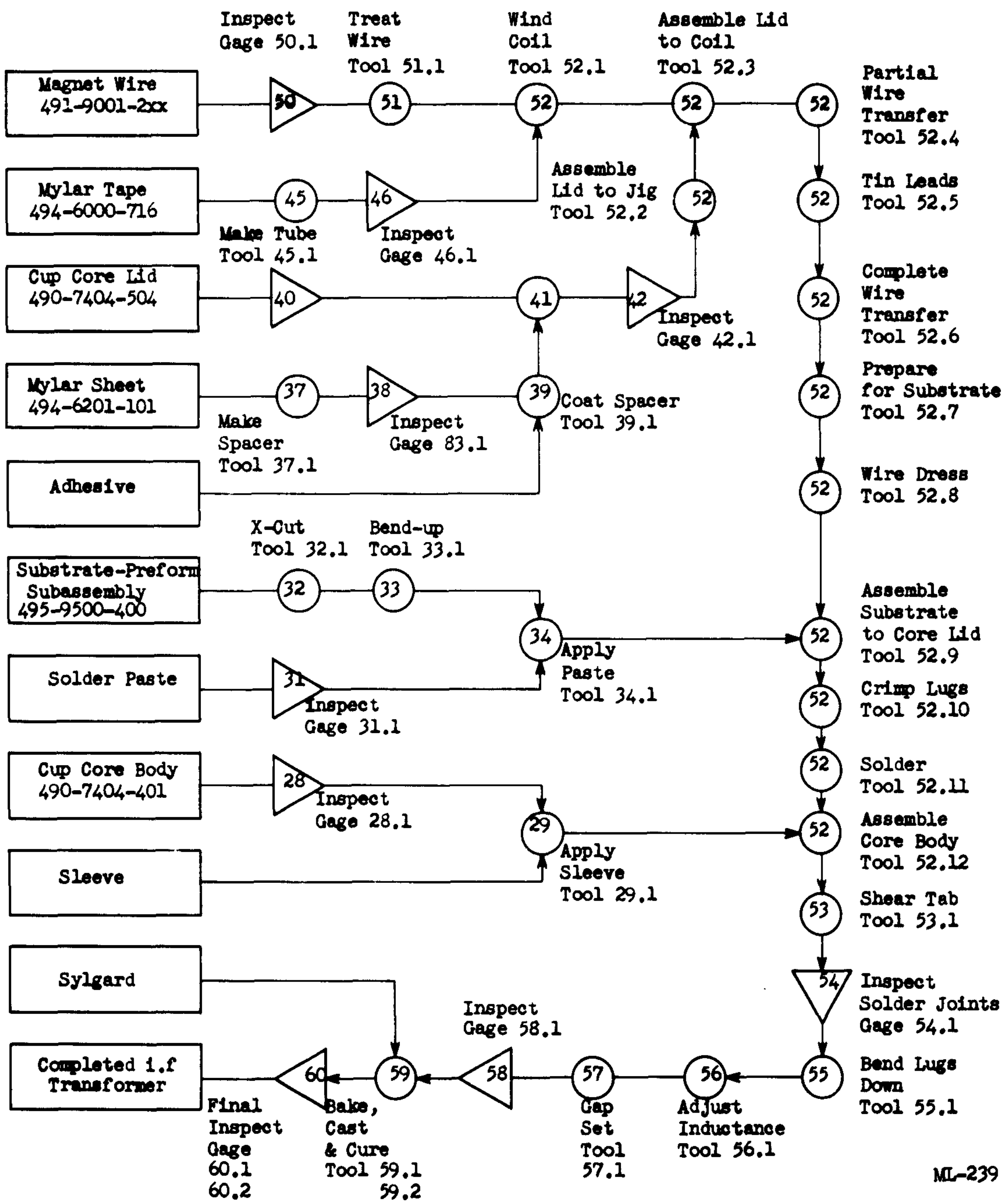


Figure 3.2.3-6. Flow Chart for Collins Radio I-F Transformer

than the Indiana General cores, the same coil performance will be obtained except for the high temperature coefficient indicated below:

	OUTSIDE DIAMETER (inch)	TEMPERATURE COEFFICIENT* (ppm/°C)
Ferroxcube Core	.223	250 - 300
Indiana General Core	.229	100 - 120

* The temperature coefficient of both materials is linear over the range from -55°C to 85°C.

IF Trimmer Inductor Microelements

Radio Industries has delivered range samples and has received approval to proceed with the prototype phase.

Molecular Dielectrics has delivered 200 glass-mica substrates with the .258-inch square cavity and pedestals to accommodate the Radio Industries Micro-Module pot core and can. These substrates were made with a combination mold consisting of the outside section of the existing single-cavity tool and a square insert section provided by Radio Industries. Addition of pedestals to allow for magnet wire under the pot resulted in an increase in the over-all microelement height of approximately .020 inch. Molecular Dielectrics may be able to reduce this height increase with future tool design.

RCA and Molecular Dielectrics attempted to weld a metal spider (produced by Radio Industries) to the wafer metalization. The results were not satisfactory and work on this welding technique was abandoned. However, Radio Industries has replaced this technique by soldering magnet wire directly to the substrate metalization.

Radio Industries supplied 20 prototype microelements made with the above substrates and commercial-grade ferrite materials. Test data supplied with these microelements are reproduced in Figure 3.2.3-7 and Table 3.2.3-8. Prior to assembly into test modules, a retest of the unloaded "Q" parameter revealed erratic trim behavior on five units. Analysis of these units by Radio Industries disclosed cracked cups and broken strands. The remaining units are being processed to develop reliable module-assembly and encapsulation processes for this "end trim" type of module assembly. Practical processing procedures for both "top trim" and "terminal-end trim" are being developed.

Radio Industries anticipates having temperature-stable (TC-3) magnetics from Indiana General Electronics for their final grade 455 kc demonstration. They have now received full sets of TC-4 (high-frequency ferrite), and will demonstrate 15 megacycle performance by fabricating the required 12 samples by the end of this quarterly period.

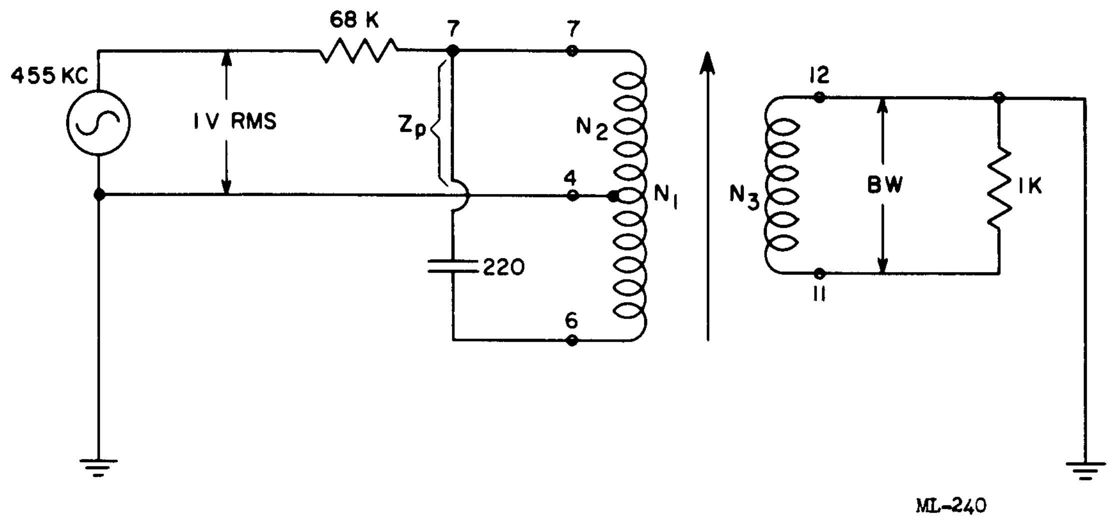


Figure 3.2.3-7. Test Circuit for Trimmer Microelements

3.2.3.4 COLLINS -- HIGH-FREQUENCY FIXED-INDUCTOR MICROELEMENTS

As previously reported last quarter, Collins had submitted prototype samples which satisfied the electrical requirements but had mechanical shortcomings. The substrate for this subtask is the same as that used for the medium-frequency fixed-inductor microelement prepared by Collins. Therefore, the acceptance of the Collins high-frequency units will indicate a resolution of the substrate problems under this task.

3.2.3.5 CAMBRIDGE THERMIONIC - "D" CORE FIXED INDUCTOR MICRO-ELEMENTS

Cambridge Thermionic completed final-grade demonstration microelements and delivered them with "Q"-meter data. The inductor is a 0.215 microhenry reactor for operation at 88 megacycles.

The Cambridge Thermionic data supplied on approximately 100 microelements showed they met the inductance uniformity target of ±5% and bettered the ±15% unloaded-Q uniformity target by a considerable margin. These inductors were carefully hand wound and showed a Q range of ±5%. Cambridge Thermionic believes ±10%, which is acceptable in most applications, will permit use of the hand-operated winder they are developing for the "D" core.

TABLE 3.2.3-8
RADIO INDUSTRIES TEST RESULTS FOR PROTOTYPE
TRIMMER MICROELEMENTS

SERIAL NUMBER	BANDWIDTH AT 3 DB IN KC	N1 to N2 VOLTAGE RATIO	N2 to N3 VOLTAGE RATIO	UN-LOADED Q	LOAD-ED Q	PRI IMPEDANCE (ohms)	INSERTION LOSS
1	13	2.7	4.4	70	37	9520	6.7
2	13	2.7	4.4	91	46	9520	6.3
3	13	2.7	4.4	79	39	9248	6.8
4	12	2.7	4.4	77	43	9248	6.5
5	13	2.7	4.4	76	38	9248	6.5
6	12.6	2.7	4.4	84	45	9520	6.5
7	11.6	2.7	4.4	71	41	9248	
8	12	2.7	4.4	75	43	18020	6.5
9	12.9	2.7	4.4	79	40	9248	6.8
10	12	2.7	4.4	84	45	9520	6.5
11	11.9	2.7	4.4	91	44	9520	6.5
12	12	2.7	4.4	72	35	9248	6.7
13	12.3	2.7	4.4	89	44	9520	6.3
14	11.6	2.7	4.4	106	47	9520	6
15	12.6	2.7	4.4	75	40	8364	6.3
16	12	2.7	4.4	101	49	11016	6
17	11.9	2.7	4.4	89	46	9520	6.3
18	11.5	2.7	4.4	97	47	9520	6.3
19	12	2.7	4.4	89	44	9248	6.3
20	11.2	2.7	4.4	78	42	9520	6.3

MT-30

Test module standards were selected and 60 units were assembled into test modules and encapsulated at RCA. Life-test microelements were assembled in modules with three microelements per module; and environmental test modules were assembled in modules with a single element per module. The test modules were returned to Cambridge Thermionic for final life and environmental test measurements which will be made during the next quarter.

Cambridge Thermionic's data on the elements which were encapsulated for environmental and life testing are reproduced in Table 3.2.3-9. The inductance (L) is computed from the Q meter capacitance when the elements are resonated at 88 megacycles with the microelement soldered to A.W.G. No. 22 buss between the instrument terminals. The precise Q value is obtained by accounting for the corrections due to test equipment losses.

TABLE 3.2.3-9
CAMBRIDGE THERMIONIC DATA FOR FINAL-GRADE "D" CORE, 88-Mc FIXED INDUCTOR MICROELEMENTS

NO.	INDUCTANCE (L) IN µH	QUALITY (Q)	NO.	INDUCTANCE (L) IN µH	QUALITY (Q)	NO.	INDUCTANCE (L) IN µH	QUALITY (Q)
77	.215	97	107	.223	99	136	.226	98
78	.218	97	108	.229	98	137	.215	101
80	.227	97	110	.211	97	138	.217	101
81	.221	99	111	.224	98	139	.220	101
82	.226	101	113	.220	100	140	.220	100
83	.217	93	115	.223	97	141	.221	97
84	.221	102	116	.218	101	144	.226	98
85	.221	102	119	.218	101	147	.220	100
86	.217	100	122	.226	95	148	.221	99
90	.223	101	123	.217	98	150	.223	99
91	.226	100	124	.215	97	152	.214	97
92	.221	101	126	.224	93	153	.220	94
93	.226	101	127	.221	96	154	.217	98
94	.223	101	128	.229	98	155	.210	102
95	.229	97	129	.227	999	156	.221	100
99	.223	98	130	.221	101	157	.214	103
101	.221	99	131	.229	100	159	.213	99
102	.221	98	132	.221	100	160	.220	97
103	.220	100	134	.221	100	161	.214	95
105	.217	99	135	.218	100	167	.220	99

MT-31

3.2.3.6 UNITED TRANSFORMER -- AUDIO TRANSFORMER AND CHOKE TOP-ELEMENTS

United Transformer has been approved as a supplier for the module-size audio transformers which are complete module units.

During this quarter, United Transformer was given approval to proceed with final samples. RCA recommended that a fixture be used to center the DIT transformer on the alumina substrate and to align it perpendicular to the substrate. Control of the extension of the transformer leads below the substrate also was recommended so that the element will stack flat in module assembly. UTC has promised to evaluate the effects of solder touching the side of the transformer can during dip-soldering of the module.

United Transformer will consider the use of a heavier substrate on future units to avoid breakage, and smaller transformer-lead holes to achieve more reliable soldering. The minimum over-all microelement height that can be presently guaranteed is 0.4 inch; a waiver is being requested to permit this. UTC expects to complete the task during the next quarter.

3.2.3.7 RCA INDUCTOR PACKAGING DEVELOPMENT

The principal objective of this task was to process the existing RCA core and coil into a substrate compatible with the RCA header-type, solder-dip method of module assembly. This was accomplished by means of a deep, glass-bonded-mica substrate developed by Molecular Dielectrics.

Seven of the prototype modules used for demonstration were subjected to environmental qualifying tests and were found to be acceptable. At the end of 24 hours of moisture-resistance testing, one unit had an insulation resistance of 300 megohms between the windings; the required value is 1000 megohms. However, the insulation resistance rose above the 1000 megohms limit within a week.

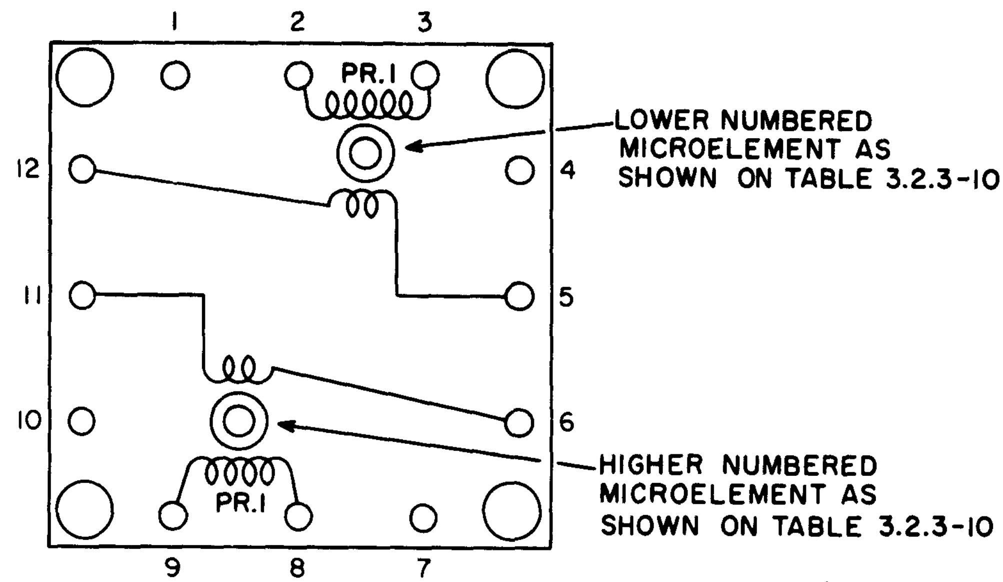
Thirty-four of the prototypes, which had two elements per module, completed 2000 hours of life testing with no failures. These units were aged in an 85°C oven with a polarizing voltage of 45 dc volts applied through a one-megohm resistor between the primaries and secondaries. The required 25 units were delivered to SurfCom. Data on these units are shown in Table 3.2.3-10; the test wiring arrangement is shown in Figure 3.2.3-8.

TABLE 3.2.3-10
LIFE-TEST RESULTS FOR RCA PROTOTYPE INDUCTOR PACKAGES

MODULE NUMBER 1828-	MICRO-ELEMENT NUMBER	AS ENCAPSULATED			AFTER 500 HRS			AFTER 1000 HRS			AFTER 2000 HRS			
		L	Q	Lsc*	L	Q	Lsc*	L	Q	Lsc*	L	Q	Lsc*	IR(megΩ)
- 1	6	2.12	95	1.36	2.10	95	1.30	2.10	94	1.31	2.10	93	1.29	$9x10^6$
	7	2.25	96	1.37	2.23	96	1.33	2.23	96	1.34	2.23	95	1.35	$20x10^5$
- 7	25	2.09	94	1.33	2.06	94	1.28	2.06	94	1.28	2.06	93	1.27	$20x10^5$
	26	2.19	93	1.41	2.16	93	1.36	2.16	93	1.36	2.16	92	1.36	$30x10^5$
- 8	27	2.16	94	1.38	2.14	94	1.34	2.14	93	1.34	2.14	92	1.32	$9x10^6$
	28	2.16	94	1.28	2.14	94	1.23	2.15	93	1.24	2.15	92	1.22	$7x10^6$
- 9	29	2.14	94	1.37	2.11	94	1.34	2.12	93	1.34	2.12	92	1.33	$15x10^5$
	30	2.10	93	1.31	2.08	94	1.28	2.08	93	1.28	2.07	92	1.27	$15x10^5$
-10	31	2.15	96	1.38	2.14	96	1.36	2.14	95	1.36	2.14	94	1.35	$7x10^6$
	32	2.24	90	1.57	2.23	91	1.54	2.22	90	1.55	2.22	89	1.53	$7x10^5$
-12	35	2.04	93	1.20	2.03	94	1.15	2.03	92	1.15	2.02	92	1.14	$15x10^6$
	36	2.26	94	1.42	2.25	93	1.38	2.25	94	1.38	2.25	93	1.38	$30x10^5$
-13	37	2.11	94	1.39	2.10	95	1.37	2.10	93	1.35	2.10	93	1.37	$9x10^5$
	38	2.21	95	1.40	2.20	95	1.38	2.20	94	1.39	2.20	94	1.38	$7x10^6$
-14	39	1.93	92	1.18	1.91	92	1.14	1.92	92	1.13	1.91	91	1.12	$7x10^6$
	40	2.09	95	1.30	2.07	94	1.30	2.07	94	1.30	2.07	93	1.28	$11x10^6$
-15	41	2.13	95	1.37	2.12	94	1.34	2.12	93	1.34	2.11	93	1.34	$10x10^5$
	42	2.17	94	1.36	2.15	93	1.32	2.15	92	1.32	2.15	91	1.32	$11x10^6$
-16	43	2.13	96	1.30	2.11	95	1.29	2.11	94	1.28	2.11	92	1.28	$30x10^5$
	44	2.22	93	1.45	2.20	93	1.42	2.20	92	1.42	2.20	91	1.42	$8x10^6$
-17	45	2.13	94	1.42	2.12	94	1.40	2.12	94	1.41	2.11	92	1.40	$7x10^6$
	46	2.07	93	1.36	2.06	92	1.36	2.16	91	1.36	2.05	91	1.34	$7x10^6$
-18	47	2.13	94	1.37	2.12	94	1.36	2.12	93	1.37	2.11	92	1.35	$15x10^6$
	48	2.11	93	1.32	2.10	93	1.30	2.10	91	1.30	2.10	91	1.30	$10x10^6$
-19	49	1.92	94	1.19	1.92	94	1.18	1.92	92	1.18	1.91	92	1.17	$9x10^6$
	50	2.09	94	1.30	2.07	94	1.30	2.07	92	1.30	2.07	92	1.30	$7x10^6$
AVERAGE		2.11	93.6	1.34	2.10	93.6	1.31	2.11	92.7	1.31	2.10	91.8	1.30	$6.3x10^6$

*Primary Inductance with the Secondary Shorted.

MT-32



ML-241

L: Apparent inductance in microhenrys as read with no corrections for Jettron 71-080 socket on board plugged into terminals of Boonton Type 260A 'Q' Meter at 7.9 megacycles.

Q: Unloaded quality factor of primary read under same conditions as L above.

Lse: Same as L except with low-reactance shorts soldered across terminals 5 and 12 and 6 and 11.

I_R: Insulation Resistance between terminals 2 to 5 (for lower numbered inductors) and 6 to 8 (for higher-numbered inductors) as measured with teflon module socket and a Mid-Eastern Megatrometer Model 710.

Figure 3.2.3-8. Life Test Arrangement for RCA Prototype Inductor Packages

3.3 SEMICONDUCTOR DEVICES

Objective and Status

The purpose of Program Extension II, Production Engineering Measure, for semiconductor devices is to establish capability for manufacturing a broad line of micro-element transistors and diodes. The tasks consist of the following three phases:

Phase I - Demonstration of package hermeticity and compatibility with micromodule processing techniques. This phase has been completed.

Phase II - Demonstration of ability to meet electrical performance requirements and establishment of device specifications. Two-hundred units of each type are to be supplied.

Phase III - Demonstration of facilities in a preproduction run. Three-hundred units of each type are to be supplied.

The status of the above program is as follows:

Texas Instruments and Sperry Semiconductor have successfully completed all the requirements of Phase I and Phase II. These vendors have received approval to proceed with Phase III.

Fairchild, Hughes, and MicroSemiconductor have successfully completed Phase I and all testing required for Phase II, but have not yet been granted approval to begin Phase III. This approval will be forthcoming during the next quarter.

Philco and General Electric have successfully completed Phase I, and are now engaged in the Phase II effort.

RCA has successfully completed the Phase I effort on the VHF power transistor. Phase II effort on this transistor has reached the testing stage. Two germanium transistors are also being fabricated by RCA as part of this effort. The TA-2229 has completed 1000-hour temperature aging. A yield problem has delayed the TA-2029 Phase II program by six weeks although units were placed on aging on December 14, 1962.

The Program Extension II, Production Engineering Measure for semiconductor devices consists of two additional tasks which evolved from Tasks 31 and 32. The Diode Mounting Task (MMDP 32-4) is concerned with establishing a capability of reliably attaching diodes to ceramic wafers by welding. The Ultrasonic Cleaning Task (MMDP 31-7) is concerned with establishing a capability for ultrasonically cleaning semiconductor devices without degrading the electrical characteristics of the elements.

3.3.1 TRANSISTORS, PROGRAM EXTENSION II, PEM, TASK 31

3.3.1.1 2N705 GERMANIUM MESA TRANSISTOR

Texas Instruments has successfully completed all requirements of Phase II. A final specification has been established and approved by the Signal Corps and Texas Instruments is fabricating the required 300 preproduction test elements needed from the Phase III effort.

3.3.1.2 2N328A SILICON-ALLOY JUNCTION TRANSISTOR

Sperry Semiconductor has successfully completed all the requirements of Phase II and the final specification has been approved by the Signal Corps. This company has also fabricated the 300 preproduction test elements required for Phase III; these units were placed on 1000-hour, high-temperature aging, scheduled for completion by mid-January.

3.3.1.3 2N501A GERMANIUM AND 2N495 SILICON TRANSISTORS

The Philco effort has suffered several delays because of faulty TO-46 stems. The initial lot of stems supplied to Philco had cracked glass seals resulting in nonhermetic packages. An additional lot of stems from the same vendor indicated that the hermetic sealing problem had been solved; however, incorrect lead sizes and incorrectly located butt welds caused further rejections.

Samples of 30 type TO-46 headers, representing the most recent stem shipment, were evaluated and found acceptable. Philco established new delivery schedules for stems and, based on these dates, a "manufacturing start time" for fabrication of the Phase II transistors was set for the last week in November.

3.3.1.4 SILICON VHF POWER TRANSISTOR; TA-2029 AND TA-2229 GERMANIUM TRANSISTORS

The RCA 400-mw, 70-mc transistors completed 1000-hour 200°C temperature aging and were started in Phase II acceptance testing. A problem occurred with reduced 70-mc amplifier and oscillator power outputs of the microelements because of high-case temperatures resulting from reduced heat transfer in the test fixture. A modified method of testing these parameters will be recommended by RCA at the completion of the Phase II Program. It is noted that measurements of the oscillator and amplifier power outputs in test modules were made with reduced case temperatures. Specified requirements were met.

Three hundred RCA type TA-2229 germanium transistors have been fabricated and temperature-aged for 1000-hours. Phase II acceptance testing of these units has been started.

The yield of RCA type TA-2029 germanium transistors has been very low because of failure to meet the minimum h_{FE} requirement of 50 at 1 kc. The fabrication process for this transistor was modified to improve yield, and a second production run was completed. The units were scheduled to complete aging tests by the first week in February.

3.3.1.5 2N335 GROWN-JUNCTION SILICON TRANSISTOR

General Electric has fabricated and supplied the 50 microelement transistors required for Phase I. Tests conducted by RCA and the Signal Corps showed that these transistors meet all hermeticity requirements, and that they are compatible with module-processing techniques. These parts were placed on 1000-hour high-temperature aging, which will be completed in mid-January. General Electric was granted approval to start Phase II of its task.

3.3.1.6 ULTRASONIC CLEANING

Approximately 25 devices will be selected from each semiconductor family (having application in micro-modules) for subjection of ultrasonic-energy tests. General types will be selected from the approved sources developed under Tasks 18, 19, 31, and 32. All units will be tested in unencapsulated test modules. The ultrasonic cleaning system used will be that developed for the PEM Program. The parameters tested will include h_{FE}, I_{CBO}, and $V_{CE(sat)}$ for the transistors, and I_R and V_F for the diodes. Data analysis for degradational effects and a failure analysis for all catastrophic failures will be conducted. Details of this program are being written and will be submitted for approval during the next quarterly period.

3.3.2 DIODES, PROGRAM EXTENSION II, PEM

3.3.2.1 1N658 GENERAL-PURPOSE SILICON DIODE

Fairchild's Phase II testing program on the 1N658 diode is almost complete. Only shock and vibration tests of the Group-B inspection remain to be performed. A faulty test fixture caused the initial microelement wafers to crack in test. Fairchild test data revealed the following major problem areas:

Group-A Tests — High-temperature reverse current (I_R at 150°C) was barely within the specified limit of 25 microamperes. Fairchild must select a lower-leakage device for Phase II to assure that an adequate margin exists for this parameter during the Phase III effort.

Group-B Tests — The fixture used for shock and vibration tests was inadequate, as indicated by the excessive number of broken test wafers. The fixture is being redesigned to accommodate the standard RCA test module. Satisfactory completion of the test is expected during the next reporting period.

The Fairchild technique for mounting diodes to wafers consists of welding, to the molybdenum studs of the diode, nickel ribbons which are brazed to the land area by the wafer vendor (CFI). This technique allows the microelement to be aged at temperatures up to 300°C without loosening the diode. With most of the data completed and reviewed, it can be concluded that Fairchild has successfully completed the requirements for the engineering sample phase of the program. Negotiations for the final specification are now underway with Fairchild and will be concluded when the data from the second source (MicroSemiconductor) is obtained.

The Phase II testing program at MicroSemiconductor is nearing completion. Group-A results have been satisfactory with the 200 units conforming to the specifications.

MicroSemiconductors' Group-B test results indicate that test fixtures for performing the shock and vibration tests represent the only major problem area. This problem has been resolved by allowing them to perform this test with the microelement encapsulated into the standard RCA test module. This change has been standardized to include all diode and transistor microelements. The Group-C tests indicated that three of the storage-life test elements broke away from the ceramic wafer after the 175°C storage-life test. Cold-solder joints and leads which have not been stress relieved are believed to be the cause. MicroSemiconductor will analyze these mechanical failures and develop a new diode-mounting process which will be verified with additional samples prior to their proceeding into the Phase II Program. Negotiations for a final specification are complete and have Signal Corps approval.

3.3.2.2 1N750A MICROSEAL ZENER DIODE

The scheduled Phase II Program at Hughes for this diode has been completed. Analysis of the storage life test failures (4 units) indicate that the problem area is one of faulty internal connections. Hughes is presently conducting a failure analysis and upon conclusion will recommend corrective action.

The secondary problem of external shorts caused by solder creepage and trapped flux residues, causing conductive paths across the wafer, has been solved. Hughes recommended a number of process and material changes to solve the problem. They have prepared samples with the revised process and high temperature aging tests are being conducted to verify corrective action. The proposed changes include:

a. Ceramic wafer thickness and metalization, will be reduced from .031 ±2 to .028 ±2 inch.

b. The mounting solder will be changed from 62.5% Sn/36.1% Pb/1.4% Ag (M. P. 179°C) to 95% Sn/5% Sb (M. P. 238°C).

c. Kester No. 1544 Rosin Flux will be used in place of a zinc-chloride flux.

The final specification for this 4.7 volt microelement Zener diode has been negotiated successfully and Signal Corps approval has been obtained. Hughes will begin work on the Phase III effort as soon as the above problem area can be resolved. A minimum program delay of two months is expected.

Diode Mounting

The task of mounting diodes by means of a small resistance welder has been carried forward with a continuing investigation of the weldability of various materials. A new welding head has been designed and is scheduled for completion early in the next quarter. An addendum to the standard land and lead specification has been written for weldable wafers. In addition, a preliminary process standard for "Welding Component Leads to Micro-Module Wafers" has also been prepared for specific diodes.

To date, the best materials for welding are, in order: platinum, palladium, nickel, Kovar, and silver. The optimum wafer consists of a .002-inch-thick nickel plating with a gold flash above the basic metalizing. Results of the welding investigation completed to date are described in the following paragraphs:

The welding method used depends upon the alloying of the lead material with metalization material. The heat generated by the weld causes the metal of the lead and the metalization material between the two weld electrodes to melt and alloy together. The ability to achieve welds by this technique is a function of many factors, the most important of which are:

a. metalization material and thickness

b. lead material and thickness

c. energy and pressure setting of the welding head

d. electrode shape and tip spacing.

Figures 3.3.2-1 through 3.3.2-4 show some of the effects of welding materials of various thicknesses and shapes. Figure 3.3.2-1 shows the condition which results when the wafer metalization thickness is much less than that of the lead material, i.e., the material between the electrodes is essentially vaporized. Under these conditions, the heat setting is quite critical, and a slight reduction in heat results in very little alloying, leaving a cold, non-adherent joint. A decrease in the electrode spacing to concentrate the heat energy, and a decrease in heat setting results in either a cold joint or a "cut", as shown in Figure 3.3.2-1.

Figure 3.3.2-2 shows the more ideal conditions, i.e., the wafer-metalization mass is more like that of the lead material. In this instance, both materials are melted between the electrode spacings, and an alloy puddle is formed. The metalization retains its adherence to the substrate and most of its physical form with no splash or excess puddle spreading.

Figure 3.3.2-3 shows the condition which can result when excess energy is applied under the same conditions of Figure 3.3.2-2. Alloying and puddling occur over a larger area, metalization adherence is lessened in the area of the joint, and splashing (or partial vaporization) has occurred. Even though the joint may meet some minimum strength requirement, it has lost a high percentage of its normal strength.

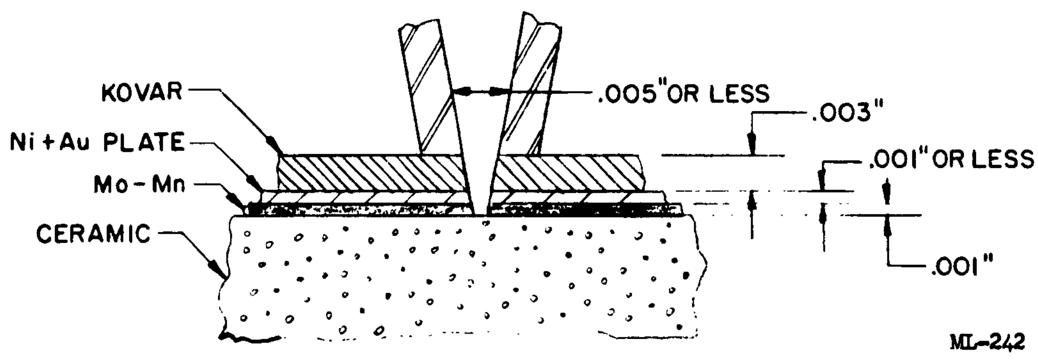


Figure 3.3.2-1. Resulting Condition When the Wafer Metalization Thickness is Less Than Thickness of Lead Material

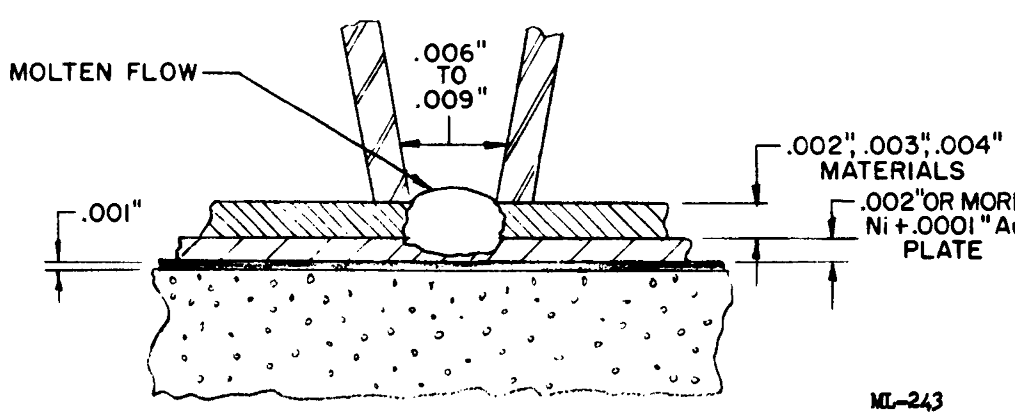


Figure 3.3.2-2. Shows an Ideal Condition When the Wafer Metalization is Similar to the Lead Material

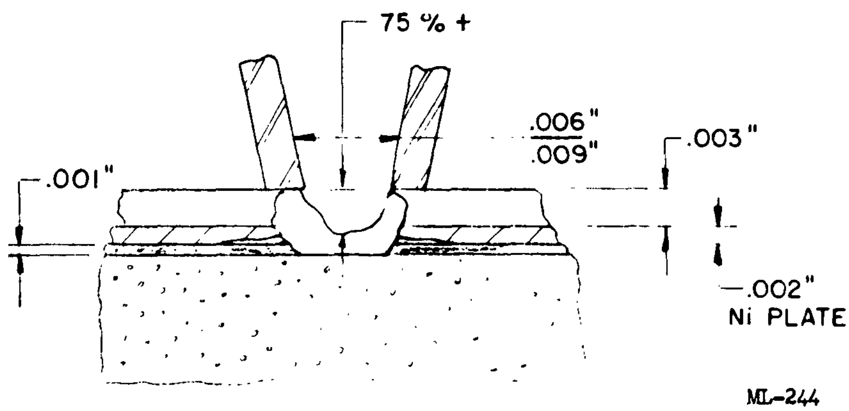


Figure 3.3.2-3. Resulting Condition When Excess Energy is Applied Under the Same Conditions of Figure 3.3.2-2

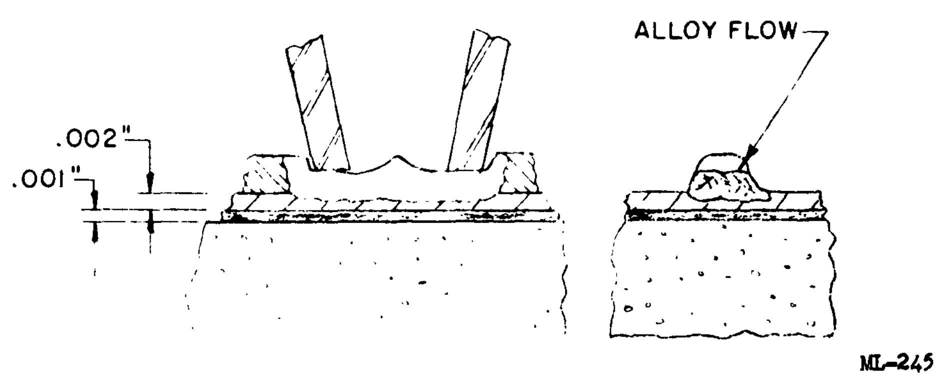


Figure 3.3.2-4. Visual Effects on a Correctly Welded Round Lead

The observed effects on a correctly welded round lead are shown in Figure 3. 3. 2-4. Deformation of the lead is apparent when proper alloying has taken place. When viewed from the end, a spreading of the alloy puddle is evident. As with flat lead materials, insufficient heat energy results in a cold, non-adherent joint; overheating results in partial vaporization as indicated in Figure 3. 3. 2-3.

Wafer Metalization — Diode-mounting wafers with various materials and material thicknesses were examined for weld capability. Some results are given in Table 3. 3. 2-1. The optimum metalization thickness was found to be in the order of .002 inch. The materials found to be compatible to this welding technique, in order of weldability, were: platinum, nickel, silver, and copper. Since nickel is a standard material used in wafer metalization, most effort was directed toward the use of nickel for a weldable diode-mounting wafer. A thin gold plating on the nickel enhances weldability in that it prevents surface oxidation and acts as a flux when alloying occurs.

Lead Materials — Of the materials for diode leads, evaluated to date, the following materials when used in conjunction with .002 inch-thick nickel plating and gold plate on the wafer resulted in good alloy welds (in order of preference):

a. platinum

b. palladium

c. nickel (soft electronic grade)

d. Kovar

e. silver

Negative results were obtained with Dumet and Rodar leads. Even though these lead materials could be welded to each other by conventional welding techniques, no combination of the parameters of this alloy-weld technique at present provides an acceptable weld. The problem appears to be one of getting these lead materials to alloy with the wafer metalization.

Weld Characteristics — The data shown in Table 3. 3. 2-1 make possible these general observations:

a. In welding to alumina wafers, the thickness of the metalization must be nearly equal to the thickness of the lead material being welded. For example, .003-inch nickel ribbon could be easily welded to .002 inch nickel plating (No. 28), whereas the same .003 inch nickel ribbon welded poorly to .001 inch nickel plating (No. 27). No. 1 and No. 12 .003 inch Kovar welded very well to .002 inch nickel plus .0001-inch-gold plate and poorly to .001-inch-nickel plate. Similar results were obtained with Micalex wafers, as shown by tests No. 15 and 14.

TABLE 3.3.2-1
RESULTS OF WELDING TESTS OF VARIOUS MATERIALS
(Sheet 1 of 2)

TEST NO.	MATERIALS: WAFER METAL OR STRAP (inch)	MATERIALS: LEAD (inch)	OPTIMUM WELDER SETTINGS: ELECTRODE SPACING (inch)	OPTIMUM WELDER SETTINGS: HEAT*	OPTIMUM WELDER SETTINGS: FORCE (lb)	WELD QUALITY
	Alumina Wafer	Kovar				
1	.002 Ni + .0001 Au	.003 x .019 + Au	.008	2	2	very good
		Rodar				
2	.002 Ni + .0001 Au	.010 diam	.008	2 3/4	2	bad
3	.002 Ni + .0001 Au	.004 x .020 Au	.008	2 3/4	2	poor
	Nickel Strap					
4	.003 + .0005 Au	.001 diam	.008	3	2	poor
		Dumet				
5	.002	.016 diam	.008	5	2	bad
6	.002	.008 strap	.008	5	2	poor
7	.002 + .0001 Au	.008 strap	.008	5 1/2	2	poor
		Kovar				
8	.003 + .0005 Au	.003 + Au	.008	7	2	very good
9	.002	.003 + Au	.006	1 1/2	1 1/2	very good
	Alumina Wafer					
10	.001 Ni	.003 + Au	.006	1 1/2	1 1/2	bad
	Nickel Strap	Rodar				
11	.002	.010 diam	.008	3	2	bad
12	.003	.010 diam	.008	3	2	bad
	Alumina Wafer					
13	.002 Ni + .0005 Au	"Incusil" preforms	.008	1	2	very good
	Micalex Wafer	Kovar				
14	.0007 Cu	.003 x .019 + Au	.006	.9	1 1/2	bad; Cu peels
15	.0007 Cu + .003 Ni	.003 x .019 + Au	.006	6	1 1/2	very good
		Nickel				
16	.0007 Cu	.003 x .015	.006	1 1/4	1 1/2	bad; Cu peels
17	.0007 Cu + .002 Ni	.003 x .015	.006	2	1 1/2	bad
18	.0007 Cu + .003 Ni	.003	.006	7	1 1/2	good
19	.0007 Cu + .003 Ni	.003 + Au	.006	7	1 1/2	very good
		Copper				
20	.0007 Cu + .003 Ni	.002 + Ni	.006	6	1 1/2	bad (cuts)
		Nickel				
21	.0007 Cu + .001 Ni	.003	-	-	-	bad (cuts)
		Copper				
22.	.003 Ni + .0005 Au	.002 + Ni	.006	8	1 1/2	bad (cuts)
23.	.0007 Cu + .003 Ni	.002 + Ni	.006	8	1 1/2	bad (cuts)

*Dial setting for Weldmatic welding machine.

MT-33

TABLE 3.3.2-1
RESULTS OF WELDING TESTS OF VARIOUS MATERIALS
(Sheet 2 of 2)

TEST NO.	MATERIALS		OPTIMUM WELDER SETTINGS			WELD QUALITY
	WAFER METAL OR STRAP (inch)	LEAD (inch)	ELECTRODE SPACING (inch)	HEAT*	FORCE (lb)	
24	.002 Cu + gold flash	.003 x .015 Kovar + Au	.008	3	2	good
25	.002 Cu + gold flash	.003 x .015 Kovar + Au	.008	5	2	very good
	Alumina Wafer	Platinum				
26	.001 Ni + .0001 Au	.004 x .018	.008	1 1/2	1	excellent
27	.002 Ni + .0001 Au	.004 x .018	.008	2 3/4	1	excellent
		Nickel (electrical grade)				
28	.002 Ni + .0001 Au	.003	.008	2 1/4	2	excellent
29	.001 Ni + .0001 Au	.003	.008	1 1/2	2	poor
		Dumet Strap				
30	.002 Ni + .0001 Au	.004	-	-	-	bad
		Silver				
31	.002 Ni + .0001 Au	.004 + Au	.008	2 1/2	2	very good
	Kovar Strap	Kovar				
32	.003 x .019	.003 x .019 + Au	.008	2 1/4	2	very good

MT-33

*Dial setting for Weldmatic welding machine.

b. The above generalization does not apply to noble metals. As noted in items No. 26, No. 27, and No. 31, good welds were achieved in every case. In item No. 26, the plating thickness was much less than that of the lead material being welded.

The heat and pressure settings given in Table 3.3.2-1 were established by trial and error based on visual observation of the weld, i.e., insufficient heat and pressure did not cause the lead material to melt; too much heat and pressure caused a sputtering of lead material and, in some cases, a complete cut. A more optimum setting resulted in a flow and alloying of the lead materials in the area between the weld electrodes. The quality of the welded joint was determined by observation and pull-strength tests; i.e., the weld was considered good if an observed alloying took place, and the pull strength of the joint (in the plane of the wafer) was in the order of the material itself and/or the adherence of the wafer metalization.

3.4 CRYSTALS, PROGRAM EXTENSION II, PEM

The purpose of the crystal Production Engineering Measure is to develop sources of microelement crystals and to resolve processing problems associated with crystal production. Phase I of the PEM was an analysis phase in which three suppliers (Midland, Bulova, and McCoy) produced and tested sample microelement crystals to demonstrate capability. Samples were encapsulated in test modules and evaluated. Each supplier submitted a process analysis report, including test data. The reports and test results were used to determine the extent of production facilitation required.

A pre-implementation phase was established to incorporate and demonstrate design revisions suggested during the analysis phase. Midland has successfully completed this pre-implementation phase and is proceeding with the implementation phase.

3.4.1 MIDLAND MFG. CO.

Midland has acquired all of the production equipment and associated tools and fixtures required to make the 60 preproduction samples, the fabrication of these samples has started.

Mitronics has delivered to Midland 275 of the required 2500 crystal packages for the preproduction and pilot-run samples. Of the 275 packages, 79 were rejected by Midland primarily for improper location of the mounting pins. However, the over-all quality of these packages has greatly improved over earlier samples and the packages now meet specified requirements. The quality improvements were achieved by Mitronics (1) by the design of a brazing fixture to locate the mounting pins, (2) tighter metalization tolerances to control the solder build up on the inner cavity diameter and (3) by more rigid quality control. Midland established inspection controls on incoming packages. A Unitron, Model TM, toolmakers and metallurgical microscope will be used to measure the spacing between mounting pins.

The yield from Mitronics crystal package production must be improved to obtain a practical cost level. A review of the package design and specifications is planned for this purpose.

Midland has prepared a process manual for microelement crystal production which includes a flow chart (Figure 3.4.1-1) and process specifications.

A silk screen for metalizing the blank crystal with Hanovia silver was purchased by Midland. The screen was unsatisfactory because of poor pattern definition and because the photo resist material did not withstand the cleaning process. Accordingly, RCA, Somerville made a stainless steel screen and sent it to Midland for use in the preproduction run.

The need to improve the quality and production of the solder seal operation was recognized by Midland. A multiple sealing jig was designed and minor refinements were incorporated in the final equipment.

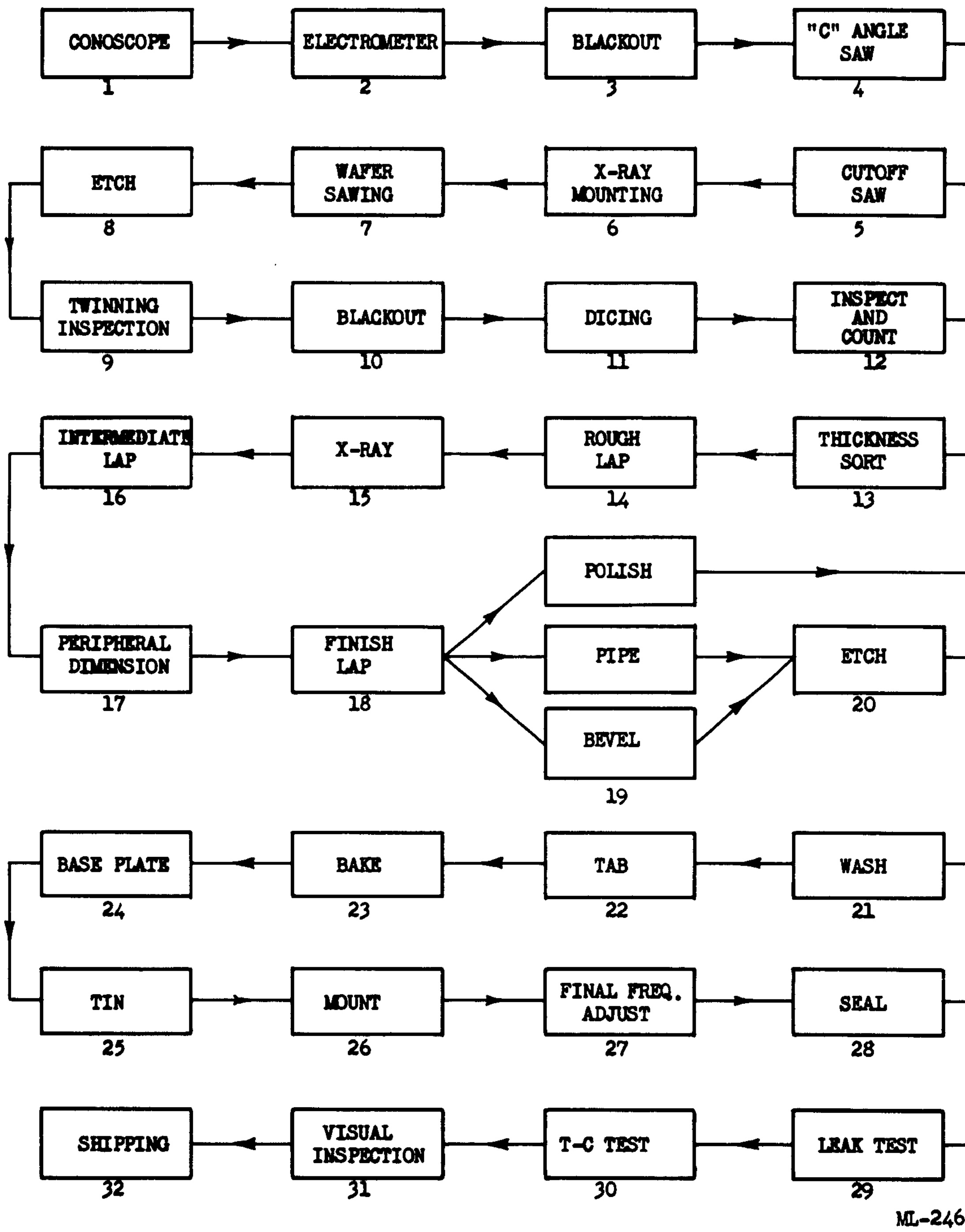


Figure 3.4.1-1. Proposed Flow Chart for Midland Crystal Production

The PEM quartz crystal Specification (RCA Dwg No. 8522711, Revision A, 31 October, 1962) has been issued and submitted to the Signal Corps for approval.

3.4.2 BULOVA ELECTRONICS DIVISION

A joint meeting was held on November 1, 1962, at Bulova to discuss progress on the microelement crystal task. Representatives from RCA, Somerville and Surf Com were present. Completion of the task effort, including test and delivery, was scheduled for June 1, 1963.

Since Bulova could not procure ceramic crystal packages from RCA, Lancaster at a reasonable cost, it was recommended that another source be established. In this connection, a package proposal from Isotronics, Inc., was considered by Bulova as a possible source, which if acceptable, would not delay the task completion beyond June 1. However, if a second source cannot be established in time, Bulova can use the 20 to 25 packages which were made by RCA, Lancaster. These units are sufficient to fulfill the 15 sample requirement of the Design Plan.

3.5 MATERIALS AND TERMINATIONS, PROGRAM EXTENSION II, PEM

3.5.1 MATERIALS

Objectives and Status

Work is being performed under this Program on encapsulation and soluble spacers, whose objective is to develop a process which will minimize cost, improve module yield and reliability, and be adaptable to a high rate of production.

3.5.1.1 ENCAPSULATION

The Blendmaster machine, which was procured for production encapsulation of shell modules, was modified to improve performance. The manufacturer, the Hull Corporation, changed the actuating system from an oil-hydrualic method to an air system, which Hull is using on its latest models. The heating jacket on the resin cylinder was modified to provide a greater area of heating contact, and a mechanical binding problem was corrected by the manufacturer.

Tests were run to establish the best temperature controls for the cylinder, nozzle and materials, with the following results:

CYLINDER TEMPERATURE (°C)	NOZZLE TEMPERATURE (°C)	POUR TEMPERATURE (°C)
24-25	88	56
24-25	99	63
24-25	104	67
24-25	110	61
24-25	121	76
40	99	64
55	99	66
65	99	68
70	99	72

A pouring temperature of 65 to 70°C is satisfactory for encapsulation. If the nozzle temperature cannot maintain a satisfactory pour temperature when the resin is at ambient temperature under continuous operation, it is necessary to apply heat to the cylinders.

Preliminary encapsulation tests were made with five inductor test modules. The resin was maintained at ambient temperature, the nozzle was kept at 104°C, and the pour temperature was 67°C. Four inductor test modules were also encapsulated with a resin temperature of 70°C, the nozzle kept at 99°C, and the pour temperature at 72°C. The modules were cured for two hours at 85°C and three hours at 125°C. Two modules from each group were cycled from -65°C to +125°C with no evidence of

cracking. Two modules from each group were cross sectioned; there was no evidence of any voids.

Manufacturing Standard 2025828 was written to cover the operation of the Blendmaster machine.

3.5.1.2 COATING

The centrifugal casting equipment and the coating racks were received, tested, and placed in production. A DC-271-M11 viscosity test was made over a one-week period, during which time no daily corrections were made for viscosity changes. A liter of the solution was prepared and put into a vacuum desiccator.

The following test was carried out:

a. The lid was taken off the desiccator for 15 seconds.

b. A vacuum (up to 25 inches of Hg.) was applied to the solution, and then broken.

c. The lid was taken off the desiccator for 20 seconds, and then replaced.

These results were obtained:

	VISCOSITY INDEX (seconds at 25°C)
Original solution	28
End of 1st day (7 tests)	30
End of 2nd day (5 tests)	31.6
End of 3rd day (3 tests)	33
End of 4th day (3 tests)	34
End of 5th day (3 tests)	34.5

During operation, viscosity will be checked each morning and adjusted to be within the range of 24 to 28 seconds with methyl ethyl ketone. If necessary, DC-271-M11 will be added to maintain volume.

3.5.1.3 MARKING

Tests indicated that the best marking parameters were a pressure of 10 pounds/in^2, a head temperature of 475°F, a dwell time of 0.7 second on the front stage and 1.6 seconds on the back stage, and a reduced closing speed of the marking head on the module.

Six modules containing two resistors per module were encapsulated in shells (type EM60) with Stycast 2651-40 and cured for two hours at 85°C and three hours at 125°C. Marking was performed by using the above parameters. Table 3.5.1-1 shows the resistance in ohms of the respective modules after coating, encapsulation, thermal cycling, and marking. Results indicate that the resistance was not affected by these various processes -- particularly marking.

Six support studs were made for the module top-holding jig. The studs have different lengths to accommodate modules from 0.150 to 1.05 inch high, thereby permitting use of a constant set of marking parameters. A group of modules of different lengths was assembled for encapsulation and marking. The group of modules can be characterized as follows:

Modules #1 to #8 were 0.250 inch long and contained a resistor directly under the end-wafer on the top and the bottom.

Modules #9 to #16 were 0.500 inch long and contained a resistor on the top and bottom. No end-wafer.

Modules #17 to #18 were 0.750 inch long and contained a resistor on the top and bottom. No end-wafer.

Modules #19 to #22 were 0.750 inch long and contained a resistor directly under the end-wafer on the top and bottom.

The modules were encapsulated with Stycast 2651-40 and cured two hours at 85°C and three hours at 125°C. Marking was performed as previously outlined. Support studs were used.

Table 3.5.1-2 gives the terminal values in ohms of the respective modules after coating, encapsulation, thermal cycling, and marking. Results indicate that the resistance was not affected by any of the operations. The length of the module had no bearing on the resistance values attained after marking.

Some pointed or sharp-face type was obtained from Acromark for evaluation. The same marking parameters were used in the tests and the marking appeared to be somewhat sharper and possessed good clarity. Some of the modules listed in Table 3.5.1-2 were resurfaced to remove the marking, and then remarked with the pointed type. Table 3.5.1-3 lists the resistance values in ohms. Since the values were not affected it is evident that the pointed type did not in any way damage the resistors.

Side marking was evaluated on dummy modules by using the side-marking jig. Pressures of 10 to 20 pounds/in^2 resulted in poor clarity and pressures of 30 to 40 pounds/in^2 tended to crack the shell. These conditions occurred with the 0.007-inch face type as well as the pointed-face type. Some difficulty is encountered due to shell surface not being perfectly flat after encapsulation.

Three headers for holding type, three sets of alphabet (.003-inch face type) and two sets of numerals were ordered from Acromark. This type face was decided upon in preference to the pointed type.

TABLE 3.5.1-1

EFFECT OF MODULE PROCESSING ON MICROLECTRON RESISTORS. TWO RESISTOR WAFERS PER MODULE ENCAPSULATED IN SHELL (EMC-60)

(Sheet 1 of 2)

MODULE NO.	RESISTOR WAFER TERMINATION	RESISTANCE IN OHMS			
		AFTER COATING	AFTER ENCAPSULATION	AFTER THERMAL SHOCK	AFTER MARKING
#1	7-1	3314.5	3311.6	3312.2	3312.3
	1-11	151.44	151.42	151.49	151.49
	11-9	7944.2	7937.9	7939.1	7939.9
	9-3	3160.2	3157.9	3157.9	3157.9
#2	7-1	-	-	-	-
	1-11	-	150.98	150.99	-
	11-9	-	-	-	-
	9-3	75952	75955	76019	76052
#3	7-1	74709	74749	74729	74809
	1-11	150.84	151.23	161.04	160.49
	11-9	-	-	-	-
	9-3	74761	74779	74839	74890
#4	7-1	74929	74993	74989	75010
	1-11	161.95	162.06	162.10	162.19
	11-9	-	-	-	-
	9-3	74950	74979	74982	75009

MODULE NO.	RESISTOR WAFER TERMINATION	RESISTANCE IN OHMS			
		AFTER COATING	AFTER ENCAPSULATION	AFTER THERMAL SHOCK	AFTER MARKING
#5	7-1	74779	74824	74852	74801
	1-11	-	-	-	-
	11-9	154.69	154.74	154.75	154.72
	9-3	74619	74641	74659	74630
#6	7-1	74761	74785	74789	74812
	1-11	-	-	-	-
	11-9	152.90	153.01	152.91	-
	9-3	-	-	-	-
#7	3-10	8147.1	8148.0	8149.9	8148.2
	8-9	5548.9	5552.2	5553.4	5552.9
	7-12	8127.0	8129.9	8131.9	8130.9
	1-2	5525.9	5528.1	5529.9	5529.2
#8	3-10	8263.0	8263.9	8267.9	-
	8-9	5598.9	5599.9	5602.0	-
	7-12	8239.9	8240.9	8244.9	-
	1-2	5599.9	5600.5	5602.9	-

MT-34

TABLE 3.5.1-1

EFFECT OF MODULE PROCESSING ON MICROLECTRON RESISTORS. TWO RESISTOR WAFERS PER MODULE ENCAPSULATED IN SHELL (EMC-60)

(Sheet 2 of 2)

MODULE NO.	RESISTOR WAFER TERMINA-TION	RESISTANCE IN OHMS: AFTER COATING	AFTER ENCAPSU-LATION	AFTER THERMAL SHOCK	AFTER MARKING
#9	3-10	8248.9	8252.9	8250.9	8253.2
	8-9	5608.8	5603.9	5603.3	5604.1
	7-12	8245.1	8248.9	8415.9	8430.9
	1-2	5589.9	5592.9	5593.2	5593.2
#10	3-10	8526.1	8902.1	10040*	10887
	8-9	6388.8	6002.9	-	-
	7-12	8101.9	8103.9	8104.9	8105.9
	1-2	5577.9	5580.9	5581.0	5581.9

* Previously unstable.

MODULE NO.	RESISTOR WAFER TERMINA-TION	RESISTANCE IN OHMS: AFTER COATING	AFTER ENCAPSU-LATION	AFTER THERMAL SHOCK	AFTER MARKING
#11	4-5	1208.9	1209.5	1209.5	1209.3
	5-6	1200.8	1201.2	1201.2	1201.0
	6-12	9160.9	9162.9	9163.2	9162.0
	12-11	1646.5	1647.2	1647.3	1647.1
	11-10	1622.1	1622.9	1623.0	1623.1
	10-7	9038.2	9038.9	9039.1	9038.9
	9-11	5138.6	5138.9	5139.4	5138.9
	11-1	5135.3	5135.9	5136.1	5135.9

MT-34

Note: a. Microlectron Resistor No. 498302-2 encapsulted in Modules No. 1 to 6.

b. Microlectron Resistors No. 498302-6 and No. 498302-36 encapsulated in Modules No. 7 to No. 11.

TABLE 3.5.1-2
EFFECT OF MODULE PROCESSING ON MICROLECTRON RESISTORS.
MODULES ENCAPSULATED WITHOUT END-WAFERS
(Sheet 1 of 4)

MODULE NO.	RESISTOR WAFER TERMINA-NATION	RESISTANCE IN OHMS				MODULE NO.	RESISTOR WAFER TERMINA-NATION	RESISTANCE IN OHMS			
		AFTER ASSEMBLY	AFTER ENCAPSU-LATION	AFTER MARKING	AFTER TEMPERATURE COEFFICIENT			AFTER ASSEMBLY	AFTER ENCAPSU-LATION	AFTER MARKING	AFTER TEMPERATURE COEFFICIENT
#1	1-2	10230	10221	10226	10229	#5	1-2	10142	10137	10142	10140
	2-12	3360.9	3358.9	3360.2	3359.3		2-12	3310.0	3308.9	3310.4	3309.4
	12-7	18015	18003	18010	18005		12-7	17961	17953	17961	17956
	10-11	10210	10205	10210	10205		10-11	10176	10172	10179	10174
	11-9	3300.1	3298.2	3299.4	3298.5		11-9	3298.9	3297.5	3299.0	3298.1
	9-4	18132	18124	18131	18124		9-4	18043	18036	18044	18039
#2	1-2	10275	10266	10269	10272	#6	1-2	10139	10131	10134	10202
	2-12	3308.9	3307.1	3307.9	3308.1		2-12	3245.0	3243.5	3244.9	3244.4
	12-7	18029	18019	18023	18022		12-7	18096	18089	18094	18092
	10-11	10369	10364	10366	10362		10-11	10065	10062	10066	10064
	11-9	3327.9	3325.9	3326.9	3326.1		11-9	3298.4	3296.9	3298.3	3297.9
	9-4	18091	18084	18090	18084		9-4	17939	17930	17939	17932
#3	1-2	10133	10131	10133	10135	#7	1-2	10189	10180	10180	10214
	2-12	3327.0	3326.4	3327.3	3327.2		2-12	3278.0	3276.4	3276.9	3276.9
	12-7	18264	18259	18261	18260		12-7	17971	17962	17966	17966
	10-11	10233	10230	10233	10232		10-11	10070	10066	10070	10079
	11-9	3340.3	3339.0	3339.9	3339.4		11-9	3311.1	3309.9	3310.9	3310.3
	9-4	18135	18132	18139	18136		9-4	18035	18027	18032	18029

MT-35

TABLE 3.5.1-2
EFFECT OF MODULE PROCESSING ON MICROLECTRON RESISTORS.
MODULES ENCAPSULATED WITHOUT END-WAFERS
(Sheet 2 of 4)

MODULE NO.	RESISTOR WAFER TERMINATION	RESISTANCE IN OHMS			
		AFTER ASSEMBLY	AFTER ENCAPSULATION	AFTER MARKING	AFTER TEMPERATURE COEFFICIENT
#4	1-2	10095	10093	10096	10095
	2-12	3293.2	3292.9	3293.5	3528.5
	12-7	18184	18189	18183	18179
	10-11	10142	10142	10146	10142
	11-9	3295.0	3294.0	3295.2	3294.4
	9-4	17973	17970	17979	17970
#9	1-10	44889	44881	44880	44883
	10-11	39370	39362	39376	39359
	11-12	39796	39781	39789	39779
	12-1	44916	44900	44909	44899
	3-4	45299	45283	45299	45281
	4-5	39439	39429	39439	39429
	5-6	39440	39421	39439	39430
	6-3	44794	44772	44789	44773
#10	1-10	45039	45009	45029	45029
	10-11	39909	39882	39901	39893
	11-12	39975	39949	39969	39959
	12-1	44999	44972	44999	44981
	3-4	45329	45295	45320	45309
	4-5	39531	39508	39529	39519
	5-6	39589	39562	39589	39573
	6-3	45239	45204	45239	45219

MODULE NO.	RESISTOR WAFER TERMINATION	RESISTANCE IN OHMS			
		AFTER ASSEMBLY	AFTER ENCAPSULATION	AFTER MARKING	AFTER TEMPERATURE COEFFICIENT
#8	1-2	10072	10061	10071	10074
	2-12	3275.3	3272.9	3275.2	3274.5
	12-7	17977	17963	17975	17969
	10-11	10142	10136	10142	10136
	11-9	3315.1	3312.9	3314.9	3313.5
	9-4	17935	17924	17933	17926
#13	1-10	44642	44611	44630	44634
	10-11	39343	39331	39349	39341
	11-12	39399	39383	39399	39392
	12-1	44519	44501	44519	44510
	3-4	62069	62053	62071	62062
	4-5	50241	50221	50229	50223
	5-6	50083	50070	50079	50119
	6-3	162400	162360	162410	162410
#14	1-10	63054	63022	63065	63050
	10-11	177810	177740	177850	177820
	11-12	51600	51589	51619	51612
	12-1	63112	63109	63139	63100
	3-4	44989	44982	44999	45661
	4-5	40181	40169	40179	40649
	5-6	40169	40160	40170	40630
	6-3	45431	45420	45439	50342

MT-35

TABLE 3.5.1-2
EFFECT OF MODULE PROCESSING ON MICROLECTRON RESISTORS. MODULES ENCAPSULATED WITHOUT END-WAFERS
(Sheet 3 of 4)

MODULE NO	RESISTOR WAFER TERMINA-NATION	RESISTANCE IN OHMS			
		AFTER ASSEMBLY	AFTER ENCAPSU-LATION	AFTER MARKING	AFTER TEMPERATURE COEFFICIENT
#11	1-10	44492	45008	44851	45031
	10-11	39329	39351	39359	39361
	11-12	39162	39184	39189	39194
	12-1	45289	45330	45329	45344
	3-4	45279	45244	45269	45253
	4-5	39879	39843	39869	39851
	5-6	39763	39729	39749	39739
	6-3	44613	44579	44600	44589
#12	1-10	45249	45204	45230	45241
	10-11	39931	39894	39919	39919
	11-12	39999	39959	39979	39982
	12-1	45129	45094	45119	45120
	3-4	45349	45313	45339	45339
	4-5	39645	39613	39639	39632
	5-6	39700	39669	39690	39689
	6-3	45219	45181	45209	45199
#17	1-12	557.34	557.24	557.44	557.20
	3-4	561.29	561.09	461.49	561.19
	6-11	34625	34619	34629	34619
	11-7	34562	34549	34559	34541
	7-8	25850	25842	25846	25839
	8-9	25951	25944	25949	25939
	9-5	34559	34549	34552	34539
	5-10	34902	34899	34904	34901

MODULE NO.	RESISTOR WAFER TERMINA-NATION	RESISTANCE IN OHMS			
		AFTER ASSEMBLY	AFTER ENCAPSU-LATION	AFTER MARKING	AFTER TEMPERATURE COEFFICIENT
#15	1-10	45249	45222	45239	45249
	10-11	39479	39461	39499	39473
	11-12	39615	39600	39619	39610
	12-1	44992	44979	44992	45049
	3-4	45070	45059	45070	45112
	4-5	39710	39703	39709	39735
	5-6	39280	39273	39282	39694
	6-3	45119	45109	45119	45153
#16	1-10	45361	45349	45330	45315
	10-11	39584	39579	39569	39551
	11-12	39833	39824	39819	39800
	12-1	45259	45251	45249	45221
	3-4	45002	44999	44999	44979
	4-5	39730	39719	39719	39712
	5-6	39835	39833	39829	39811
	6-3	45160	45155	45151	45150
#20	1-12	563.95	563.89	563.89	563.92
	3-4	560.04	460.10	560.04	560.13
	6-11	17302	17301	17301	17300
	11-7	17300	17302	17301	17300
	7-8	25850	25854	25852	25862
	8-9	26007	26008	26010	26004
	9-5	34189	34189	34189	34189
	5-10	34511	34516	34513	34512

MT-35

TABLE 3.5.1-2
EFFECT OF MODULE PROCESSING ON MICROLECTRON RESISTORS. MODULES ENCAPSULATED WITHOUT END-WAFERS
(Sheet 4 of 4)

MODULE NO.	RESISTOR WAFER TERMINA-NATION	RESISTANCE IN OHMS			
		AFTER ASSEMBLY	AFTER ENCAPSU-LATION	AFTER MARKING	AFTER TEMPERATURE COEFFICIENT
	1-12	561.60	562.11	561.59	562.72
	3-4	560.81	560.82	560.70	560.49
	6-11	34432	34435	34433	34422
	11-7	34300	34300	34295	34282
#18	7-8	26077	26079	26072	26062
	8-9	25921	25919	25919	25905
	9-5	34792	34794	34789	34775
	5-10	34529	34535	34530	34514
	1-12	551.24	551.31	551.19	551.09
	3-4	560.92	560.80	560.90	560.80
	6-11	35014	35010	35011	35005
#19	11-7	34555	34544	34549	34544
	7-8	25849	25847	25851	25849
	8-9	26142	26138	26143	26201
	9-5	34931	34925	34932	34929
	5-10	34496	34494	34501	34491

MODULE NO.	RESISTOR WAFER TERMINA-NATION	RESISTANCE IN OHMS			
		AFTER ASSEMBLY	AFTER ENCAPSU-LATION	AFTER MARKING	AFTER TEMPERATURE COEFFICIENT
	1-12	561.69	561.52	561.74	561.59
	3-4	556.89	556.80	557.02	556.89
	6-11	34624	34619	34629	34619
	11-7	34510	34505	34511	34504
#21	7-8	25739	25737	25742	25739
	8-9	25962	25960	25962	25955
	9-5	33969	33969	33971	33965
	5-10	34399	34395	34400	34391
	1-12	554.09	553.89	554.10	554.09
	3-4	558.84	558.59	558.99	558.89
	6-11	34321	34312	34324	34319
#22	11-7	33934	33932	33941	33939
	7-8	25851	25843	25853	25853
	8-9	25910	25905	25911	25909
	9-5	34512	34505	34516	34511
	5-10	34309	34304	34315	34305

Notes:
a. Microlectron Resistor No. 498302-38 encapsulated in Modules No. 1 to 8.
b. Microlectron Resistor No. 498302-13 encapsulated in Modules No. 9 to 16.
c. Microlectron Resistor No. 498302-14 encapsulated in Modules No. 17 to 22.

MT-35

TABLE 3.5.1-3

EFFECT OF MARKING ON MICROLECTRON RESISTORS. TWO RESISTOR WAFERS WERE ENCAPSULATED IN EACH MODULE

MODULE NO.	RESISTOR WAFER TERMINATION	RESISTANCE IN OHMS BEFORE MARKING	RESISTANCE IN OHMS AFTER MARKING
#9	1-10	44883	44880
	10-11	39359	39349
	11-12	39779	39769
	3-4	45281	45274
	4-5	39429	39424
	5-6	39430	39425
	6-3	44773	44769
#10	1-10	45029	45021
	10-11	39893	39892
	11-12	39959	39956
	12-1	44981	44981
	3-4	45309	45309
	4-5	39519	39519
	5-6	39573	39573
	6-3	45219	45219
#11	1-10	45031	45045
	10-11	39361	39354
	11-12	39194	39189
	12-1	45344	45339
	3-4	45253	45249
	4-5	39857	39849
	5-6	39739	39731
	6-3	44589	44581

MODULE NO.	RESISTOR WAFER TERMINATION	RESISTANCE IN OHMS BEFORE MARKING	RESISTANCE IN OHMS AFTER MARKING
#12	1-10	45241	45224
	10-11	39919	39909
	11-12	39982	39973
	3-4	45339	45449
	4-5	39632	39624
	5-6	39689	39679
	6-3	45199	45365
#17	1-12	557.20	557.19
	3-4	561.19	561.03
	6-11	34619	34613
	11-7	34541	34544
	7-8	25839	25839
	8-9	25939	25939
	9-5	34539	34539
	5-10	34901	34902
#18	1-12	562.72	561.19
	3-4	560.49	5 560.33
	6-11	34422	34420
	11-7	34282	34279
	7-8	26062	26059
	8-9	25905	25904
	9-5	34775	34771
	5-10	34514	34512

MODULE NO.	RESISTOR WAFER TERMINATION	RESISTANCE IN OHMS BEFORE MARKING	RESISTANCE IN OHMS AFTER MARKING
#19	1-12	551.24	550.92
	3-4	560.92	560.59
	6-11	35014	34999
	7-8	25849	25840
	8-9	26142	26199
	9-5	34931	34919
	5-10	34496	34485
#1	7-1	3312.3	3311.0
	1-11	151.49	151.39
	11-9	7939.9	7935.9
	9-3	3157.9	3156.2
#2	7-1	Open	Open
	1-11	150.99	150.95
	11-9	Open	Open
	9-3	76052	75999
#4	7-1	75010	74949
	1-11	162.19	162.05
	11-9	Open	Open
	9-3	75009	74949
#5	7-1	74801	74809
	1-11	Open	Open
	11-9	154.72	154.66
	9-3	74630	74601

MT-36

3.5.1.4 THERMAL CRACKING

Because of the promising results previously attained by curing Stycast 2651-40 for 16 hours at 55°C, 2 hours at 85°C and 3 hours at 125°C, the procedure was applied to other types of modules. These tests were made on:

a. XM741 production modules.

b. Simulated XM730 modules. The standard refractory ceramic core was used to simulate the large inductor -- which is probably a more severe test.

c. Two groups of modules each with three inductor deep substrates. In one group, the spacing between the first and other two substrates was at the top of the module, and, in the other group, at the bottom of the module.

The thermal cycling was performed at -65°C to +125°C as per MIL-STD 202A, method 102, condition C. Results are tabulated below:

MODULE TYPE	THERMAL CYCLING		
	TOTAL	GOOD	CRACKED
XM741	55	55	0
Simulated XM730	5	4	1
Modules from (c) above	6	6	0

With a view to making Stycast 2651-40 less marginal in thermal cycling, several modifications in the Lithafrax filler were made. Lithafrax is a lithium-aluminum-silicate powder which is fired and ground. It has a thermal-expansion coefficient lower than any other filler.

Stycast 2651 with a 25 percent resin concentration was obtained from Emerson and Cuming. The filler concentrations were varied to 40 percent and 50 percent by the addition of Lithafrax #2121.

The following formulations were prepared for tests.

a. Stycast 2651-25 plus 15% Lithafrax

b. Stycast 2651-25 plus 25% Lithafrax

c. Stycast 2651-30* plus 10% Lithafrax

d. Stycast 2651-40 plus 10% Lithafrax

---

*Stycast 2651-30 was obtained by blending Stycast 2651-25 and Stycast 2651-40.

Standard dummy modules made with refractory ceramic cores with several end-wafers were encapsulated with the above combinations. The long cure cycle was used for these tests, and the standard cure cycle was also used as a comparison. The results are summarized as follows:

FORMULATION	NUMBER OF HOURS ON CURE			THERMAL CYCLING			SHELL SEPARATION
	55°C	85°C	125°C	TOTAL	GOOD	CRACKED	
(a)		2	3	10	8	2	2
(a)	16	2	3	10	15	0	1
(b)		2	3	10	7	3	2
(b)	16	2	3	5	5	0	2
(c)	16	2	3	5	5	0	2
(d)	16	2	3	10	10	0	2

In formulations (a) and (b) the standard cure resulted in a fairly high percentage of cracking. Using the long cure cycle no failures occurred with any of the formulations.

In this series of tests a slight separation of the module and the shell, partial or complete, occurred along one side. Ten other modules were also processed with Stycast 2651-40 and two shell separations were observed. This group of modules was encapsulated in long shells which had been thoroughly cleaned. At present it is not known whether the separation was the result of nonuniform adhesion, or of the use of the Lithafrax filler.

Modification of Stycast 2651 with Lithafrax appears to provide results which indicate a greater margin of safety against thermal cracking. However, further confirmation is necessary and the question of separation has to be resolved. A report covering the work done on the project has been written and will be issued.

3.5.1.5 VARIABLE TRIMMER CAPACITORS

A new method of sealing the variable trimmer capacitor is currently in the development stage. The method involves bonding an epoxy-fiber glass-cloth tubing to the wafer, and then sealing the epoxy tubing by filling it with Polarflex No. 10 prior to assembly and subsequent cleaning and coating. After encapsulation the Polarflex is removed and followed by a cutting operation. However, this technique has not been established. The technique will be investigated further during the next quarter.

3.5.2 TERMINATIONS

Summary and Status

The work on terminations in the analysis phase of Program Extension II, PEM for micro-modules was divided into four sub-tasks as follows:

a. Solder-process analysis

b. Cleaning-process analysis

c. Metalizing standardization

d. Post Termination

The tasks on solder-process analysis, metalizing standardization, and cleaning-process analysis of a group of transistors have been completed.

These tasks are discussed under "Micro-Module Assembly" in Section 3. 6. 2. The PEM Post Termination task is complete.

3.6 MICRO-MODULES

3.6.1 RELIABILITY

3.6.1.1 MODULES FOR RADIO SET AN/PRC-51 (TASK 25A)

Ninety-nine Task 25A micro-modules were placed on operating life test with junction temperatures maintained at 85°C. These communication modules have completed a total of 2,716,000 element-hours of test with no failures. Each of the 96 modules has been on test for 2,288 hours. This data indicates an MTBF for a 10-element module is 296,000 hours at 60 percent confidence. On a per-element basis, a failure rate of .033 percent per 1000 hours also has been demonstrated. Life testing on all 99 modules is still continuing.

3.6.1.2 MICROPAC COMPUTER MODULES (TASK 25B)

One hundred and seventy-six Task 25B modules have been on operating life test at 90°C to 95°C ambient temperature. These digital modules have completed 16,535,000 element-hours of test. One module failed because of a loose diode-to-wafer joint, and another module failed because of an intermittent contact in a Zener diode. The indicated MTBF for a 10-element module, therefore, is 527,000 hours at 60 percent confidence. On a per-element basis, the digital modules thus, also have demonstrated a failure rate of .019 percent per 1000 hours. Seventeen of these modules are still on test.

3.6.1.3 COMBINED RESULTS FOR TASK 25A AND 25B MODULES

Including the Task 36-1 modules, operating-life tests on modules built with current processes, have reached the level of 20,840,000 element-hours. Three modules suffered catastrophic failure during these tests. There were no degradational failures. The MTBF for a 10-element, Program Extension II, module is 499,000 hours. On a per-element basis, this represents a failure rate of .020 percent per 1000 hours.

3.6.1.4 SOLDER JOINT RELIABILITY

A total of 239.3 million joint hours of test have been logged during micro-module and microelement operating-life tests. No riser-wire-solder joints have failed during all this testing. At a 60 percent confidence level, a joint failure rate of .00038 percent per 1000 hours has been demonstrated.

3.6.1.5 REJECT ANALYSIS SUMMARY

The information reported in this section updates the data previously reported in the 18th Quarterly Report.

Out of 2,581 Task 25A and Task 25B modules produced, 328 were rejected during production and subassembly tests. Figure 3.6.1-1 illustrates in graphical form the distribution of causes of rejection.

Figure 3.6.1-2 shows the distribution of these 328 rejects with respect to the point in the module's life at which the rejects were encountered.

Figure 3.6.1-3 shows the relative frequency of rejects due to similar causes among Task 7 modules and Task 25 modules.

Cause of Failure

A. Resistors — One hundred and twenty-five of the rejected modules failed because of open resistors. The resistors in these modules failed because an area of the cermet resistor material flaked off and adhered to the Stycast encapsulant. This problem has not yet been completely solved. However, tighter controls have been imposed on the processing of the cermet resistor and on the DC-271 coating. Design reviews are continuing in an effort to completely eliminate this problem.

B. Capacitors — All of the capacitor types used in Task 25 modules have been used in previous programs except the trimmer capacitor. In previous programs as much as 30.7 percent of the rejected modules were due to cracked abradable capacitors. The design and present use of the new trimmer capacitor has cut capacitor rejects to 6.2 percent.

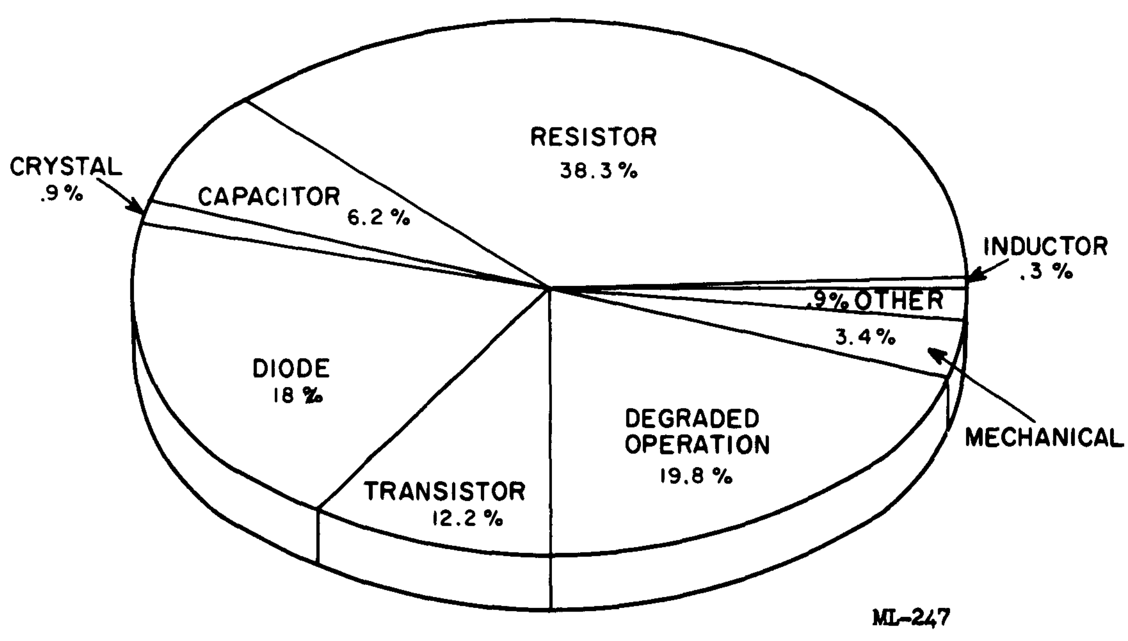


Figure 3.6.1-1. Causes of Rejection for Task 25 Micro-Modules

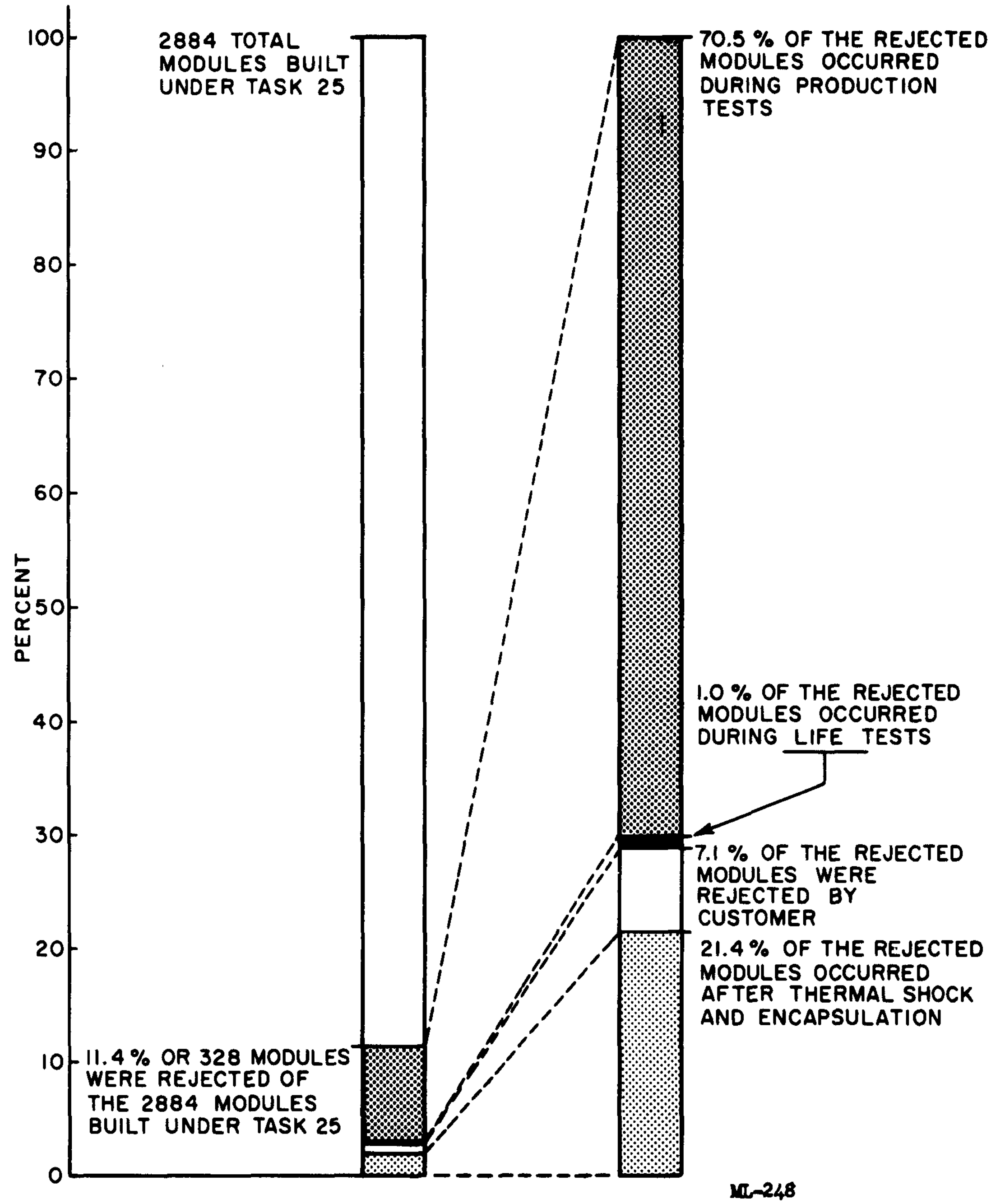


Figure 3.6.1-2. Time of Rejection for Task 25 Micro-Modules

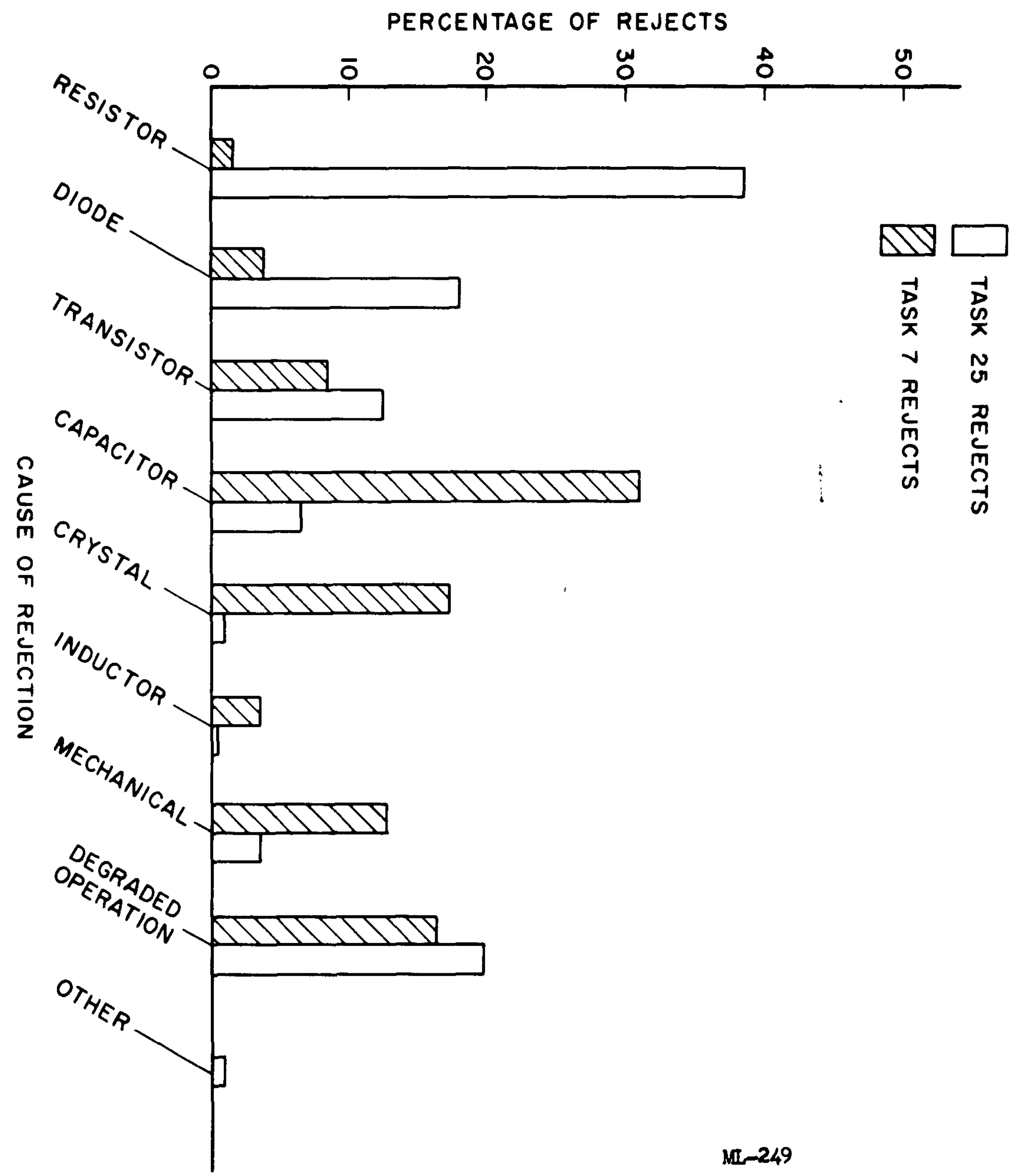


Figure 3.6.1-3. Comparison of Causes of Rejection of Task 7 and Task 25 Modules

C. Inductors — Only one module, out of 2581 built for Task 25 failed because of an inductor failure; this failure was due to a cracked core after encapsulation.

D. Diodes — In Task 25, all the diodes used were conventionally packaged miniature units soldered to a wafer frame. Nearly 90 percent of the diode failures were due to open solder joints at the point where the diode was mounted to the wafer frame. A high-temperature solder is currently in use which insures against open riser-wire joints. The welded diode-to-wafer connection, now under test, is a possible solution which requires extensive experimental development.

E. Transistors — All transistor failures were the result of shorts and burnouts due to sagging leads within the case, or poorly defined active areas on the semiconductor pellet.

F. Mechanical — 3.4 percent of the Task 25 micro-modules were rejected for such mechanical defects as:

(a) shorted riser wires

(b) missing riser wires

(c) jumpers open or missing on the end wafer.

G. Crystal — Three of the Task 25A modules failed due to open crystal units. The crystals were removed from the modules and sent back to the vendor for analysis.

H. Degraded Performance — Of the 328 rejected Task 25 modules, 56 were culled for degraded performance which meant that modules did not meet specifications on one or more parameters. These modules have not been analyzed since further testing may be requested at a later date.

3.6.1.6 DESIGN REVIEW PROGRAM

The appearance of the following two failure mechanisms prompted Design Reviews during this quarter:

a. Open diode-to-wafer joints

b. Loose Metalization

Open Diode-to-Wafer Joint

As a result of this Design Review the following actions were initiated to solve this problem:

a. A higher temperature solder is in use which will not soften during module assembly.

b. All diode joints are mechanically probed after module assembly.

c. Improved wafers have been developed by the vendor.

d. An improved solder-dipping jig can be developed which eliminates the re-dipping of diode wafers.

Loose Metalizing

Six rejects in the past two months have been caused by loose metalizing on resistor wafers. Pull tests performed by means of a hand-soldering technique showed that repeated or improper hand-soldering technique can cause failure in pull test. Pull tests on resistor wafers, which had been dip soldered showed that the present module assembly technique will provide a satisfactory joint. To avoid possible damage due to hand soldering, the repair of modules must be kept to a minimum wherever possible. At present, over 85 percent of the modules experienced at least one repair cycle. This Design Review was devoted to:

a. Minimizing micro-module repairs.

b. The repair of micro-modules without affecting module reliability.

Nine techniques for minimizing repairs were investigated and suggested by the Design Review Committee:

a. Establish 100 percent pin-gauge inspection on microelements. Figure 3.6.1-4 shows the importance of correct dimensions for microelements.

b. Train operator more thoroughly in module assembly techniques.

c. Enforce wire straightness specification.

d. Improve cascade solder-pot maintenance.

e. Demonstrate effects of repair by auditing module history sheets.

f. Minimize use of nonstandard quality products.

g. Improve module assembly techniques.

h. Provide for vendor source inspection.

i. Minimize the use of repaired elements in the repair of defective modules.

3.6.1.7 MICROPAC COMPUTER RELIABILITY ESTIMATE

In October, 1961, an estimate of 235 hours was made for the MTBF of the MicroPac Computer, based on microelement test data available at that time. Subsequently, significant additional data has been compiled including life-test data on the types of

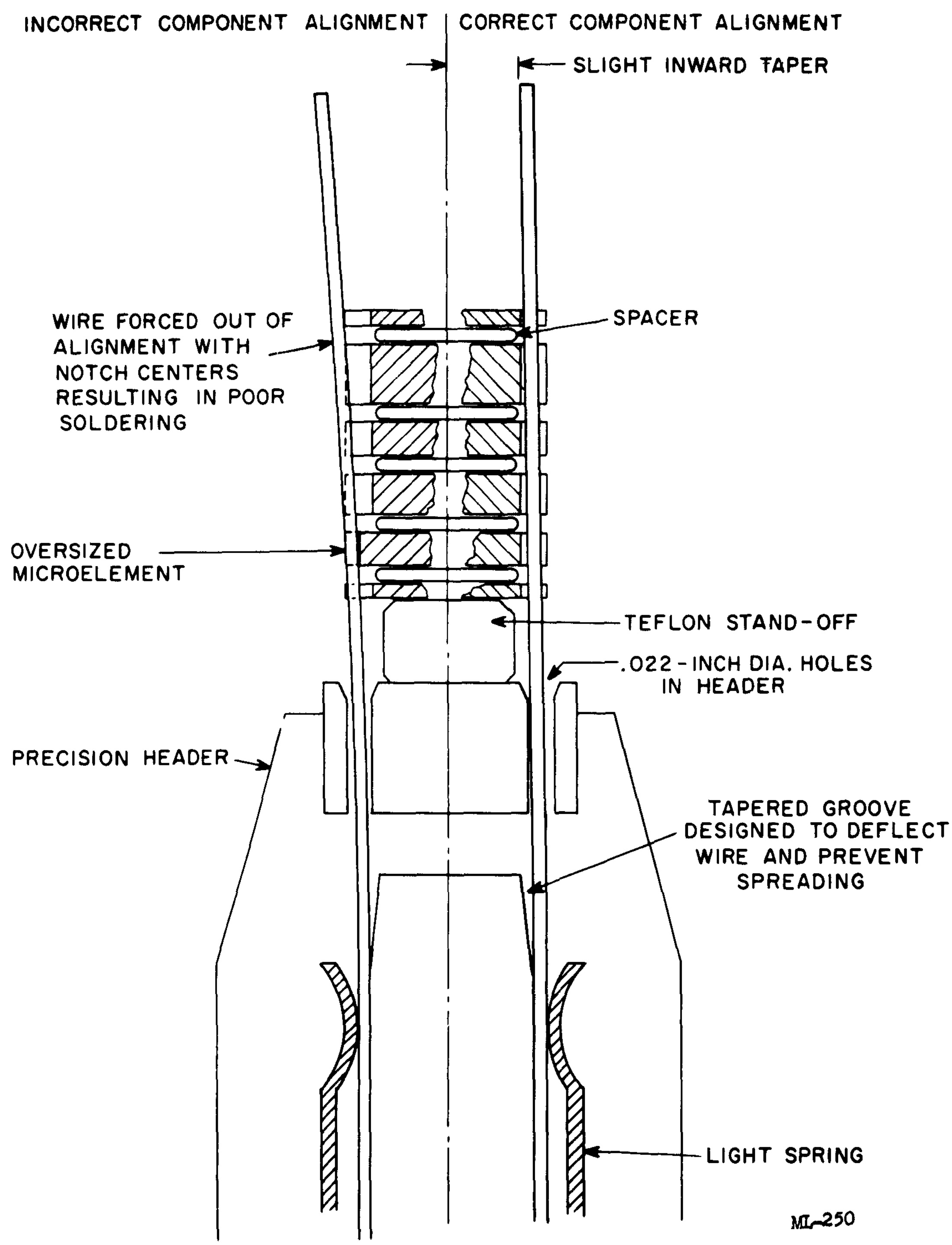


Figure 3.6.1-4. Comparison of Correct and Incorrect Methods of Microelement Alignment

diodes and transistors used in the MicroPac equipment which has permitted a significant increase in MTBF as described below:

It is the usual practice in both the micro-module and microelement test programs to conduct the tests at high-stress levels. The purpose of high-stress testing is to indicate any inherent failure mechanisms within the micro-module. Tests at high-stress levels can be related to equipment operation at normal levels by the application of conversion factors. For the purpose of this report, the conversion factors are derived from Defense Standards, Vol. 14.

As in October, 1961, the assumption must be made that the various microelements will react to derating as do conventional components. It must be further assumed, since our tests were conducted beyond the reliable limit of operation, that the curves can be safely extrapolated to encompass the level at which the tests were conducted.

Semiconductors

Storage life tests have been conducted on each type of semiconductor used in the MicroPac Program. These storage life test results are derated in a manner similar to that in the Project Design Policy Manual - Minuteman Program.

Example

A qualified vendor of microelement cermet resistors has demonstrated a failure rate of .0362 percent per 1000 hours with 125 C hot-spot loading (or 1000°C ambient) at full rated power.

Based on the curves of Figure 21B of the Defense Standards, Volume 14, "Reliability Evaluation Techniques", a conversion factor of 5.2 would be used to convert the data from the (100°C - full rated) stress level of the life tests to the (60°C - .1 rated) stress level of MicroPac usage. Thus a failure rate of (.0362/5.2) = .0069 percent per 1000 hours in such use has been demonstrated for the microelement resistor.

Similarly, calculations have been made of the failure rates for the other component types based on the microelement tests and on conversion factors from the references shown in Table 3.6.1-1. The microelement failure rates in the MicroPac equipment are also shown in Table 3.6.1-1.

Connections

The average MicroPac Computer module has 26.1 electrically significant solder-joint connections. The failure rate established for the micro-module solder-joint as the result of over 151 million joint hours of test without a failure is .00061 percent per 1000 hours. This failure is based on a 60 percent confidence with an assumed failure and is therefore very conservative. It is preferable to use the accepted RCA DEP solder-joint reliability figure of .00023 percent. All types of solder joints are included in the calculations.

TABLE 3.6.1-1

MICROELEMENT FAILURE RATES IN THE MICROPAC COMPUTER

MICRO-ELEMENT TYPE	TEST TEMPERATURE	TYPE OF TEST	TEST FAILURE RATE (%/1000 hrs)	REFERENCE FOR CONVERSION	ACCELERATION FACTOR	CONVERTED FAILURE RATE (%/1000 hrs)
Resistor (Cermet)	125°C hot spot	full-rated load life test	.0362	Figure 21B of Ref (a)	5.2	.0069
Ceramic Capacitor	85°C ambient	twice-rated voltage life test	.0065	Figure 36A of Ref (a)	100	.00007
Coils	85°C ambient	rated voltage life test	.108	Figure 43B of Ref (a)	6	.018
Electrolytic Capacitor	85°C ambient	rated voltage life test	.246	Figure 41B of Ref (a)	9.3	.026
Diodes	200°C ambient	storage life test	.507	(b)	100	.005
Transistors (average)	200°C ambient	storage life test	.453	(b)	100	.004

MT-37

(a) Defense Standards, Volume 14, "Reliability Evaluation Techniques"

(b) Project Design Policy Manual - Minuteman Program

Computer Failure Rate

Total Micro-Module Failure Rate — The micromodulized portion of the MicroPac computer contributes a failure rate of 160 percent per 1000 hours. A breakdown of the module failure rate in MicroPac is shown in Table 3.6.1-2.

MicroPac Failure Rate — As per reference (a) in Figure 3.6.1-1, the remainder of the MicroPac computer contributes a failure rate of 109 percent per 1000 hours.

Combined Failure Rate — The over-all computer failure rate is 269 percent per 1000 hours.

The MicroPac computer can expect a MTBF of 382 hours at 60 percent confidence. This estimate is an advance of 147 hours or 63 percent over the previous estimate of October 19, 1961. Contributing to this improvement are significant drops in the failure rates of microelement resistors, ceramic capacitors, and microelement inductors.

TABLE 3.6.1-2
MODULE FAILURE RATE DATA

MODULE TYPE	DWG. NO.	NO. OF MODULES TOTAL FOR COMPUTER	Transistors Per Module		Resistors Per Module		Ceramic Capacitors Per Module		Diodes Per Module		Coils Per Module		Connections Per Module		Tantalum Capacitors Per Module		Module Failure Rate	MicroPAC use Failure Rate
			No.	F. R.	No.	F. R.	No.	F. R.	No.	F. R.	No.	F. R.	No.	F. R.	No.	F. R.		
Standard Gate	XM707	81	2	.008	8	.0552	2	.00014	5	.025	0		43	.0099			.0982	7.954
Standard Gate	XM708	124	2	.008	8	.0552	2	.00014	5	.025	0		43	.0099			.0982	12.176
Low Power Gate	XM709	8	2	.008	8	.0552	2	.00014	6	.030	0		43	.0099			.1032	.825
Low Power Gate	XM710	79	2	.008	8	.0552	2	.00014	5	.025	0		43	.0099			.0982	7.757
Low Power Gate	XM711	53	2	.008	8	.0552	2	.00014	5	.025	0		44	.0101			.0984	5.215
Low Power Gate	XM713	82	2	.008	8	.0552	2	.00014	5	.025	0		43	.0099			.0982	8.052
Low Power Gate	XM714	38	2	.008	7	.0483	2	.00014	6	.030	0		43	.0099			.0963	5.659
Low Power Flip-Flop	XM718	18	2	.008	8	.0552	2	.00014	6	.030	0		44	.0101			.1034	1.861
One Shot Multivibrator	XM719	1	2	.008	8	.0552	3	.00021	3	.015	0		45	.0104			.0888	.088
Nixie Driver	XM720	46	2	.008	4	.0276	0		10	.050	0		39	.009			.0946	4.351
Neon Driver	XM721	27	2	.008	4	.0276	0		4	.020	0		31	.0071			.0627	1.692
Input Line Amplifier	XM722	12	2	.008	7	.0483	0		7	.035	0		42	.0097			.1010	1.212
Double Output Line Amp.	XM723	10	2	.008	4	.0276	0		6	.030	0		43	.0099			.0755	.755
Power Amplifier	XM724	133	2	.008	6	.0414	1	.00007	4	.020	2	.036	42	.0097			.1151	15.308
Delay Line Output	XM725	24	1	.004	4	.0276	1	.00007	0		0		24	.0055			.0371	.890
Diode Cluster	XM726	36	0		0		0		10	.050	0		26	.006			.0560	2.016
Diode Cluster	XM727	35	0		0		0		9	.045	0		24	.0055			.0505	1.767
Diode Cluster	XM728	16	0		0		0		11	.055	0		26	.006			.0610	.976
Diode Cluster	XM729	54	0		0		0		7	.035	0		24	.0055			.04050	2.187
Input Circuit Assembly	XM730	38	0		1	.0069	1	.00007	3	.015	2	.036	27	.0062			.06417	2.439
Linear Amplifier	XM731	38	3	.012	1	.0621	1	.00007	0		0		52	.012	1	.026	.11217	4.263
Gate Amplifier	XM732	38	2	.008	2	.0414	2	.00014	0		0		25	.0057			.05524	2.097
Output Amplifier	XM733	38	3	.012	3	.0621	3	.00021	1	.005	0		48	.011	1	.026	.11631	4.419
Regulator/Switch Pre Amp	XM736	14	2	.008	2	.0552	2	.00014	2	.010	0		49	.011			.08434	1.180
Regulator/Switch Out Amp	XM737	14	2	.008	0	.0138	0		2	.010	2	.036	28	.006			.07380	1.033
Decoder Gate Assembly	XM738	47	2	.008	2	.0552	2	.00014	10	.050	0		54	.012			.12534	5.889
Memory Strobe Input	XM739	1	2	.008	0	.0276	0		2	.010	0		37	.009	2	.052	.10660	.107
Strobe Inhibit Gate	XM740	1	2	.008	2	.0483	2	.00014	1	.005	0		38	.009			.07044	.070
Shift Register	XM741	211	2	.008	4	.6900	4	.00028	6	.030	0		50	.012			.14023	29.582
Input-Output Sampler	XM742	2	1	.004	2	.0207	2	.00014	3	.015	2	.036	36	.008			.08384	.167
Standard Flip-Flop	XM752	114	2	.008	2	.0552	2	.00014	6	.030			44	.01			.10334	11.776
Strobe Pulse Amp	XM753	1	2	.008	2	.0552	2	.00014	1	.005	0		45	.01	1	.026	.10434	.104
Shift Register Driver	XM754	24	2	.008	1	.0345	1	.00007	8	.040	1	.018	44	.01	0		.11057	2.652
Four Inductor Module	XM755	6	0		0		0		0		4	.064	22	.005	0		.06900	.414
Memory Address Sw. Assem.	XM788	28	2	.008	2	.0276	2	.00014	1	.005	0		32	.007	0		.04774	1.335
Digital Driver Output Assem.	XM790	38	2	.008	2	.0276	2	.00014	2	.010	0		35	.008	0		.05374	2.040
Standard Gate	XM1026	59	2	.008	2	.0483	2	.00014	5	.025	0		29	.007	0		.08844	5.215
Standard Gate	XM1027	43	2	.008	2	.0552	2	.00014	5	.025	0		42	.01	0		.09834	4.226
		1632																157.749
Non-Standard Modules		24					5	.00035			5	.090					0903	2.167
		1656																159.916

MT-38

3.6.2 MICRO-MODULE ASSEMBLY, PROGRAM EXTENSION II, PEM

3.6.2.1 OBJECTIVES AND STATUS

The analysis phase of Program Extension II, PEM for micro-modules, had as its objective the development of a module-assembly process suitable for implementation as a micro-module production facility. This effort is essentially complete except for the life testing of one additional final-grade module type. The implementation phase of the PEM for modules has as its objective the design and procurement of module-assembly facilities in accord with the above established module assembly processes. The design and procurement of these module-assembly facilities are essentially complete. Construction of RCA-built equipment is approximately 85 percent complete.

3.6.2.2 MICRO-MODULE TESTING

Design and construction of the digital-module test set is complete. Component parts for the test-fixture chassis for digital modules of Tasks 36 and 39 have been procured. The design of the communication-module test set is essentially complete, and construction has started.

3.6.2.3 PROCESS INTEGRATION

The design of the mold for casting polyvinyl-chloride masking plugs on micro-modules prior to the coating operations has been modified slightly to improve module removal. A new mold has been procured, and an operating procedure has been written for shop use.

In conjunction with the use of the above masking plugs, a new leadcutting device has been designed and procured to trim all module leads to a fixed length of 0.375 inch.

A new microelement handling tray has been designed for use at the "sort and orient" operation. This tray will hold an array of 10 x 15 microelements independent of wafer thickness. A mold for making these trays has been ordered.

Procedures have either been written or are in preparation for all phases of module assembly.

3.6.2.4 MODULE ASSEMBLY

The semiautomatic dip-soldering mechanism has been attached to the cascade solder machine. Initial trial runs indicate that several minor revisions are necessary. These are: 1) A new module-holding device to simplify loading and increase production rate capability, and 2) modification of the contour of the timing cam to provide a more desirable withdrawal rate.

3.6.2.5 MICROELEMENT TESTING

Design of all microelement-test stations is essentially complete. Construction of the resistor-test station, low-frequency capacitor-test station, and the visual-and-mechanical-test station is complete. Construction of the transistor- and diode-test stations has started.

3.6.2.6 MICRO-MODULE SUB-CONTRACTORS

Mallory

A summary of the status of module-assembly facilities at Mallory is as follows:

a. Magazine Mold — The mold is complete, and 500 each of magazine types No. 1 and No. 4 have been ordered.

b. Stacking Machine — Design is complete; construction is approximately 75 percent complete. It is estimated that the machine will be completed by December 15, and will be ready for trial runs by January 1, 1963.

c. Test and Orient Machine — Design is complete. construction is approximately 85 percent complete.

d. Orient Machine — This machine is complete and is being adjusted. Basic motions were demonstrated with a few end-wafers in a magazine. Minor adjustments are required before machine will be delivered to Mallory.

e. Solder Machine — Design is complete; construction is approximately 80 percent complete. The basic motions of the machine were demonstrated. The machine consists of a ferris-wheel-type module holder and a fountain-type solder pot.

f. Cleaning Equipment — A Branson ultrasonic cleaner has been procured and is being installed. This equipment also includes a solvent-recover still. Trial runs indicate the need for further adjustment, modification and refinement.

g. Wire-Segment Cutter — Two wire-segment cutters have been procured and are being adjusted. A third wire cutter has been procured for cutting wires flush with the end-wafer.

h. Wire Straightener and Loader — Design of this machine is complete; construction has started. Mallory indicated no major problems are anticipated on the basis of the operation of a mock-up of this device. Completion of the wire straightener and loader was scheduled for December 15, 1962.

i. Encapsulation — A Hull dispenser was ordered and received. Mallory is considering use of a centrifuge technique in lieu of a vacuum. Initial trials made without preheating modules and encapsulant resulted in small voids in sectioned modules. In view of RCA's experience that the encapsulating material and modules must be preheated to eliminate voids, Mallory indicated they would continue their effort along the recommended line. They have procured a Felker Model 11B machine for module cut-off.

j. Microelement Test Equipment — Test sets for resistors and capacitors are essentially complete. The resistor test set is basically a decade bridge which includes a Quantech Noise Tester for resistor measurements. The capacitor test sets contain capacitance bridges. Two sets are complete -- one for precision capacitors and the other for general-purpose units. The test set for electrolytic units is being built. Completion of test facilities for other components was scheduled for January 1, 1963.

k. Module Test Equipment — Nearly all the commercial equipment ordered for module testing has been received. This equipment will be grouped and/or racked along with Mallory-built equipment. This test equipment was scheduled to be ready for testing by January 1, 1963.

l. Manufacturing Area — The manufacturing area for module assembly is being prepared. It is well lighted and covers about 2000 square feet.

Paktron

A summary of the status of module-assembly facilities at Paktron is as follows:

a. Module Assembler — A prototype assembly loading block has been constructed for tests. Construction of the module-assembly mechanism is continuing.

b. Segment Cutter — Design of the segment cutter is essentially complete; construction has started.

c. Encapsulation — Encapsulation facilities are essentially complete. The module cut-off machine is complete and ready for testing.

d. Marking Machine — The marking machine has been received. A device for serializing modules has been added and is being evaluated.

e. Microelement Testing — Procurement of all commercial microelement test equipment is essentially complete. Twenty test heads and 957 of 1000 slave jigs for incoming-inspection test operations have been received. Construction of resistor-, capacitor-, and visual- and-mechanical test stations has started.

f. Module Testing — All commercial equipment has been ordered. Construction and wiring of the communication-module test set has started.

3.6.3 MICRO-MODULE FOR PROGRAM EXTENSION II, EQUIPMENT

3.6.3.1 COMMUNICATIONS MICRO-MODULES (RADIO SET AN/PRC-51) TASK 25A

All required final-grade modules have been delivered. To date, a total of six out of 270 modules have been returned. All six have now been repaired or replaced.

Group-B tests are complete, and all test data have been analyzed. No catastrophic failures have occurred.

All Group-C test modules have completed their 2000-hour life tests with no catastrophic failures. The life tests for Task 25A and 25B modules will be extended to 10,000 hours. The 99 Task 25A modules were reinstated in life tests on October 26, 1962.

3.6.3.2 MICROPAC DIGITAL MICRO-MODULES, TASK 25B

One-hundred fifty-three life-test modules were removed from life test and made available for use in testing the MicroPac computer. Most of these modules had completed 6000 to 7000 hours of life test. Seventeen modules of three types remain on test. Total life-test failures remain unchanged at two modules.

The original net requirement of 1679 final-grade equipment modules has been met. An additional 162 modules have been ordered as spares. These will be delivered with tbe MicroPace computer, and will serve as field replacements. Delivery of these modules was expected be complete by December 31, 1962.

3.7 AN/PRC-51 RADIO SET

Delivery to the Signal Corps of all transmitters and receivers constituting the thirteen required AN/PRC -1 Radio Sets, was completed on October 31, 1962. Available spare micromodules were delivered on December 5, 1962. Instruction Booklets and the final report are being prepared and should be completed during the next quarter.

Figure 3.7-1 depicts the helmet receiver, R-1018( )/PRC-51, and the hand held transmitter, T-792( )/PRC-51, of the AN/PRC-51 Radio Set in experimental field use. Photographs of both assembled and exploded views of the transmitter and receiver were included on pages 3-74 and 3-75 of the previous (Eighteenth) Quarterly Report.

Figure 3.7-1. The AN/PCE-51 Radio Set in Experimental Field Use

3.8 THE MICROPAC COMPUTER

3.8.1 COMPUTER FABRICATION

3.8.1.1 PRINTED CIRCUIT CARDS

With the completion of the delivery of the printed circuit cards early in this period, the entire complement of tested booklets was inserted in the MicroPac Computer which was then made ready for a check of the logic and for system test. Figure 3.8-1 shows two completely assembled micro-module cards ready to form the booklet assembly. The completely assembled booklet array in the circuitry section is shown in Figure 3.8-2, the booklet on an extension card is shown in Figure 3.8-3 to illustrate maintenance facilitation beyond signal access via the test points.

3.8.1.2 FABRICATION TOOLS

Dip-Soldering Fixture: In order to facilitate the assembly of the micro-modules on the cards and their removal when required, various fixtures and tools were developed. A fixture, shown in Figure 3.8-4, was constructed to permit the use of dip soldering for attaching the micro-modules to the printed circuit card. The fixture was designed for the specific configuration and dimensions of the MicroPac printed circuit card. It helps to keep the card straight during dip soldering, thereby avoiding warpage, and helps also to maintain proper micro-module alignment.

Micro-Module - Ejector Tool: In unsoldering a micro-module from a printed circuit card the danger of damage lies not so much in the possible impairment of that particular micro-module but, in possible damage to the printed-circuit card which may necessitate repair or replacement of the whole card.

Requirements for the safe unsoldering of a module are as follows:

a) The unsoldering tool must be guided by definite means to the center of the wire pattern.

b) The most effective and uniform heat transfer from the unsoldering tool to each of the riser wires must take place. If one of the twelve holes of the module pattern is underheated, the module cannot be separated.

c) The local temperature to which the particular module pattern is exposed must be of proper magnitude. If it is too high, the board material may be burned. Delamination of copper conductors may also occur due to overheating. If the temperature is too low, the module will not be removable.

d) The force applied to remove a micro-module while unsoldering must be of controlled and limited magnitude. An excessively large force will cause stripping of the metal in a plated-through hole. This is demonstrated in Figure 3.8-5a, b, and c. Figure 3.8-5a shows a module prior to soldering into a double-sided

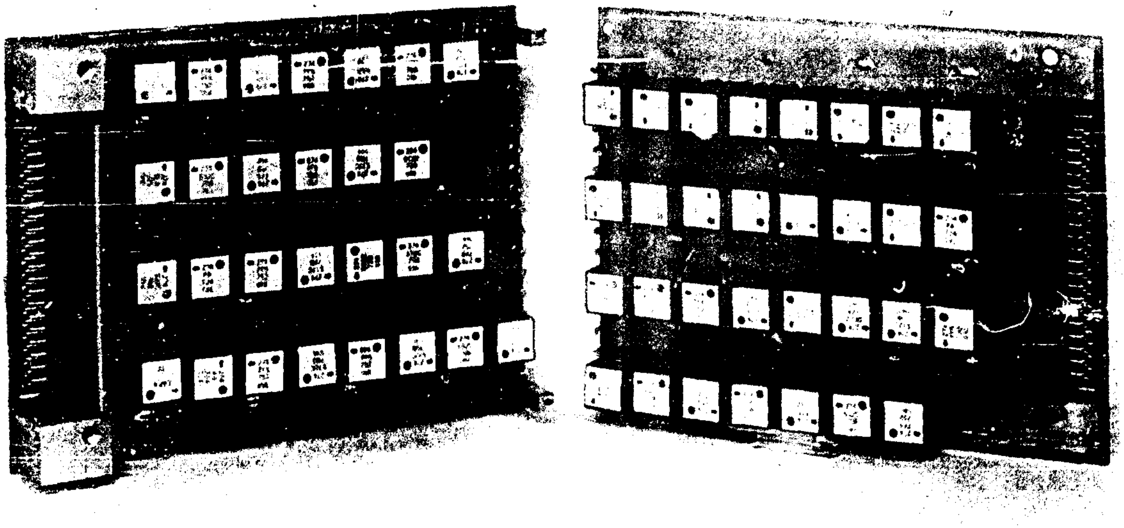


Figure 3.8-1. Completely Assembled Micro-Module Cards

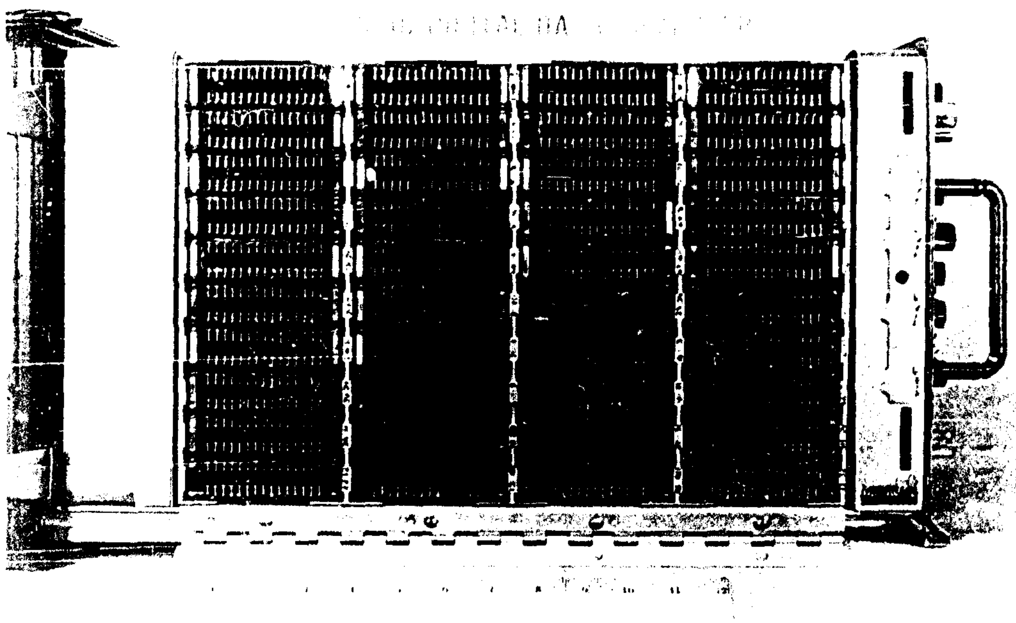


Figure 3.8-2. Completely Assembled Circuitry Section

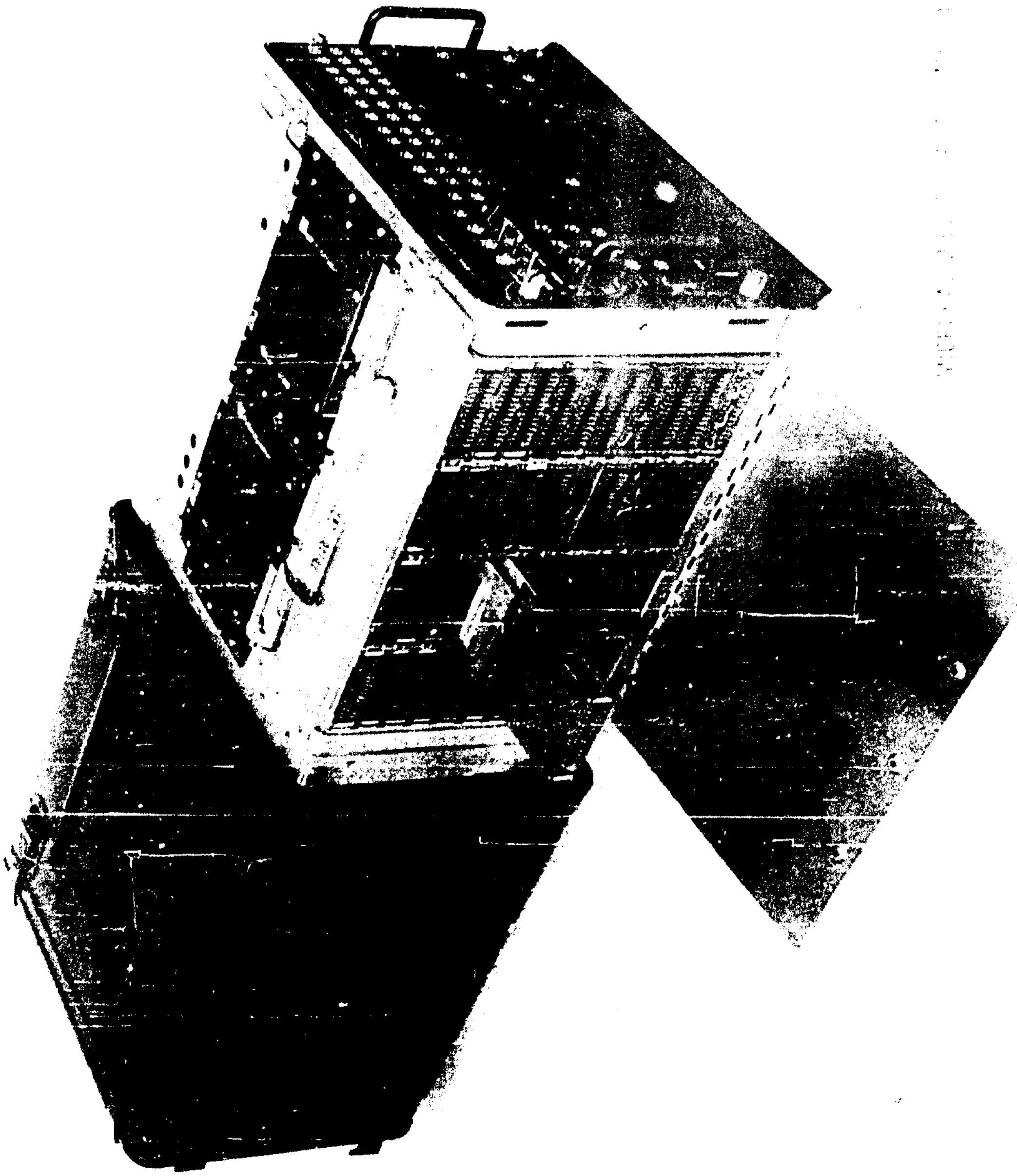


Figure 3.8-3. Booklet on Extender Card

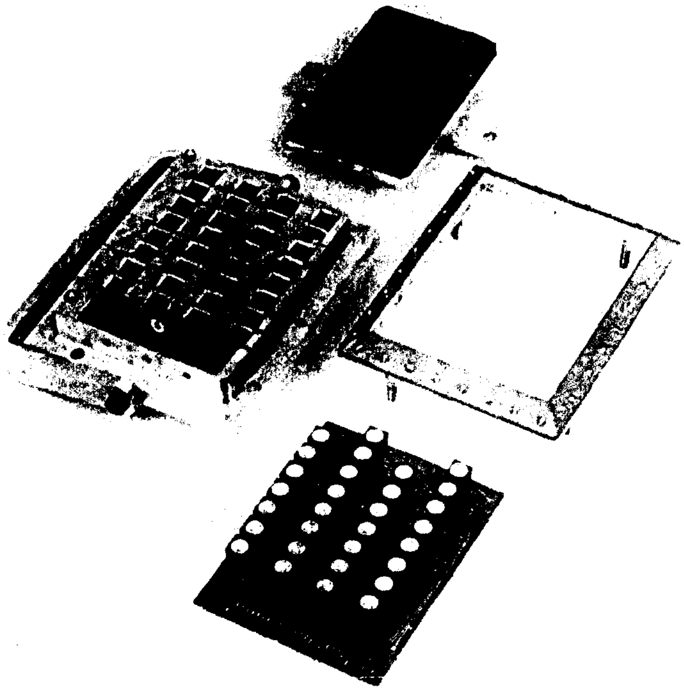


Figure 3.8-4. Dip-Soldering Fixture and Assembled Board

printed-circuit board. Figure 3.8-5b shows the solder fills between riser wires and plated-through holes after the module has been soldered in. Figure 3.8-5c shows module and card after inappropriate removal of a module. Plated eyelet on left side is shown stripped out. This card must be regarded as a total loss.

It was discovered that a micro-module could be removed with ease from a printed-circuit card by dipping the board into a liquid solder bath. Here was, indeed, the best possible heat transfer from the hot solder bath to the riser-wire pins as well as to the printed eyelet holes. In order not to adversely affect the remaining part of the board, the rest of the printed circuitry on the board was masked off and protected by adhesive tape. It was found that the module could be removed almost instantly and with ease if the solder bath was 265°C or above.

Because a solder pot may not be available in field service, it appeared desirable to develop a portable unsoldering tool based on this principle. Figure 3.8-6 depicts the tool developed. Figure 3.8-7 is a drawing of the insert assembly and Figure 3.8-8 is an exploded photograph of the insert. The soldering-iron tool must be used in an upright position with the insert at the upper end, and held in a fixture or secured to a table. Essentially, the insert is a small solder pot with the added feature of alignment and module ejection. The insert is dimensioned to fit into a Vulcan type 75, 300-watt solder tool.

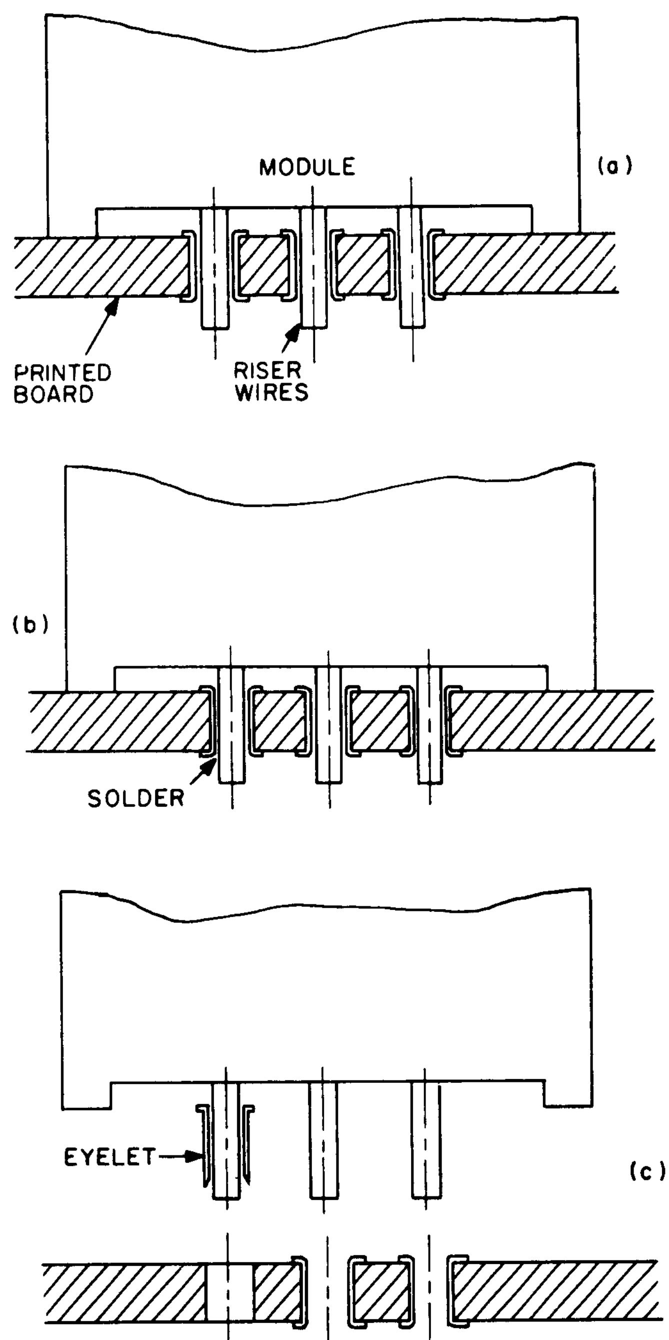


Figure 3.8-5. Micro-Module Unsoldering Aspects

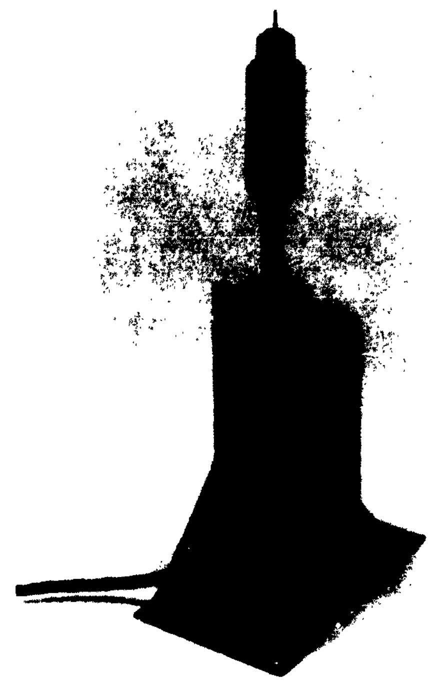


Figure 3.8-6. Micro-Module Unsoldering and Ejector Tool

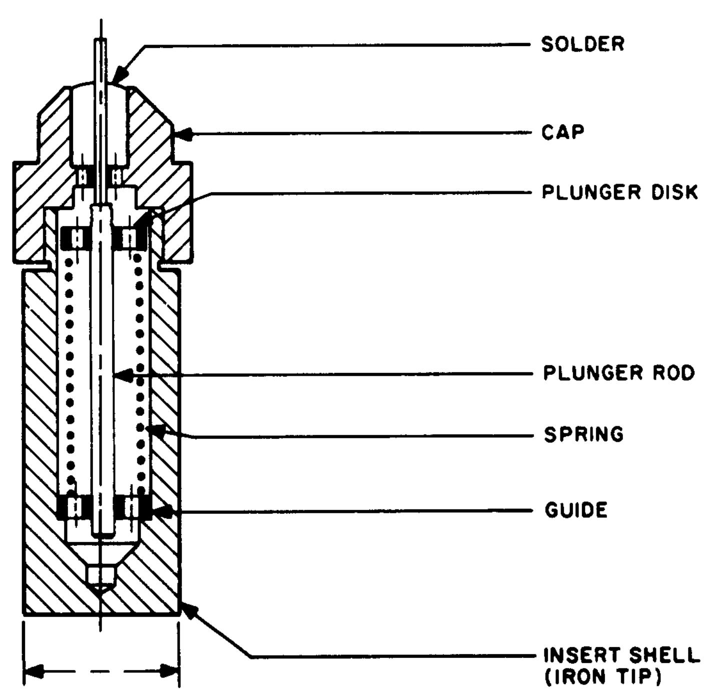


Figure 3.8-7. Micro-Module Unsoldering and Ejector Head (Sectional View)

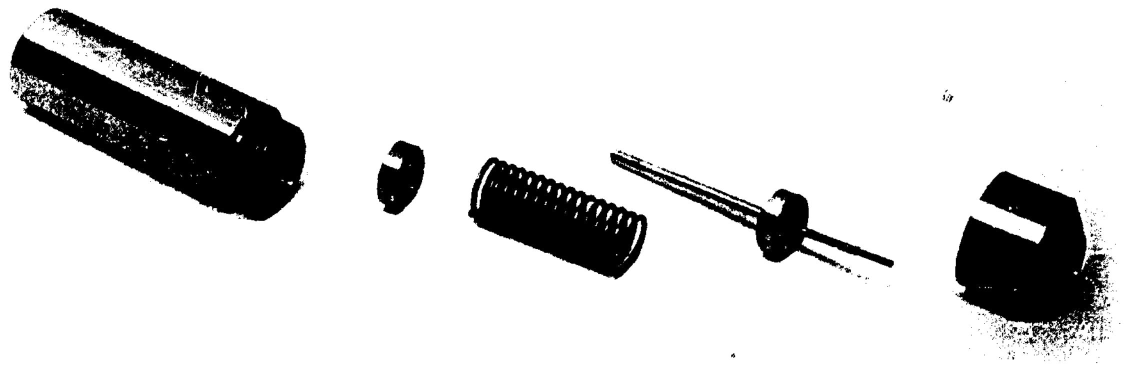


Figure 3.8-8. Micro-Module Unsoldering and Ejector Head (Exploded View)

The plunger rod and disk form a rigid unit which will slide with respect to the stationary parts. The insert is filled almost to the rim with solder. In order to retain its resilience at liquid-solder temperature, the spring is made of tungsten. Other parts of this assembly are made of stainless steel (type 303) or molybdenum to withstand corrosion from solder flux and chemical agents. To unsolder a micro-module from a printed card, the card is placed above the solder tip and brought down carefully against it. Ejection of the micro-module from the printed card takes place by action of the spring-loaded plunger shortly after the printed circuit micro-module pattern comes in contact with the liquid solder meniscus in. Due to the quick ejection of the micro-module, burning of the card or damage to the micro-module will be avoided.

Micro-Module Mounting Hole Clean-Up Tools: Upon removal of a micro-module from the printed card, the holes can be cleared of solder with a heated needle tip which will be about .003 inch smaller in diameter than the printed circuit hole. This special tip, shown in Figure 3.8-9, can be attached to a standard pencil type soldering iron and used to melt any solder bridging the printed eyelet. The Venturi vacuum equipment is used in conjunction with the soldering iron for removal of the molten solder. Made by the AIR-VAC Company of Sheldon, Connecticut, it has only recently been marketed. Figure 3.8-10 shows the arrangement of the Venturi Injector tube, with gauges and valves, filter and glass probe (the glass probe has recently been replaced by a later design by the same manufacturer). The fine orifice of the glass probe is capable of exerting a high vacuum locally to suck the solder away. As soon as the solder begins to melt, a valve which may be actuated by a foot switch will establish the required

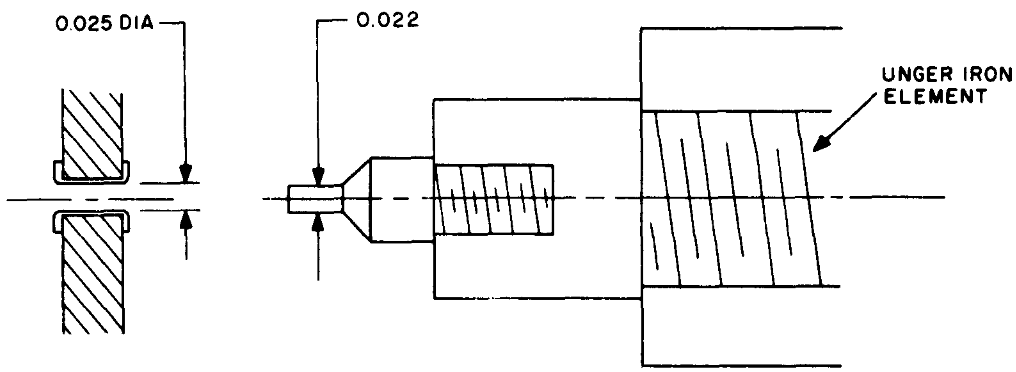


Figure 3.8-9. Micro-Module Mounting-Hole Cleaning Tip

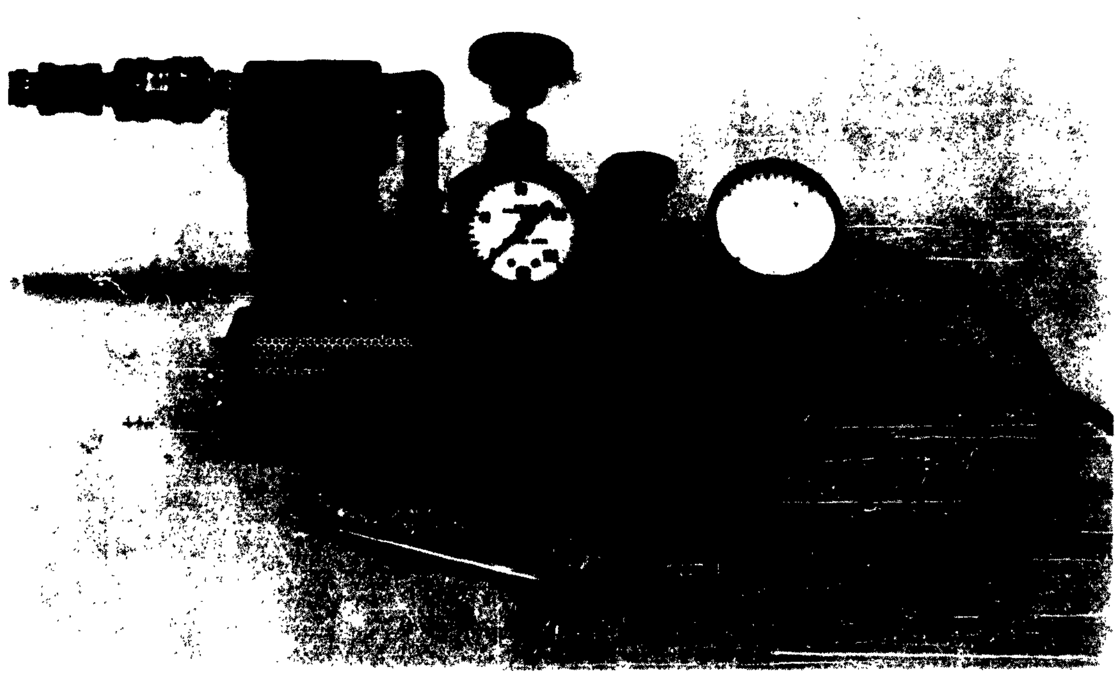


Figure 3.8-10. Venturi Vacuum Solder-Removal Equipment

vacuum, and the solder mass will be rapidly sucked into the glass probe. This model uses high compressed air such as that available in most laboratories and tool shops to achieve the vacuum required for operation of the Venturi Injector. The device replaces the popular solder tip with the well-known Teflon tip and hand squeezed ball. Prior to using this device, experiments with other devices were made. While the cost is much higher than that of a simple hand tool, its efficient action qualifies it for quality precision work of this nature.

3.8.1.3 COMPUTER ASSEMBLY

Assembly of the computer was completed including all wiring and mechanical mountings. The power supply and core memory stack were mounted in the computer as shown in Figure 3.8-11. Figure 3.8-12 shows the power supply in position with its cover in place and the voltage test points and adjustments labeled.

3.8.2 SYSTEM INTEGRATION AND TEST

Using the full complement of booklets and completely assembled system (including the paper tape subset), all twenty-one instructions were initially checked out, using manual operation, on an instruction-by-instruction basis. The power supply presented problems in two areas. In starting, the circuit breaker would open due to heavy current surge, thereby requiring several throws of the start switch (after resetting the breaker) before operation would occur. Regulation of the -9v Special and -18v supplies was not adequate. In the latter case higher stability reference zener diodes were installed to improve the regulation. The former problem comes as a result of the extremely tight packaging requirements which in turn required smaller sized components such as chokes, transformers, and special circuits. Investigation of techniques for solving this problem has been initiated.

With the memory stack at room temperature, the full instruction repertoire including input/output with paper tape subset was then tested using small program loops and the acceptance test program. Further logic and circuitry problems were resolved as they were detected. The circuitry problems involved replacing the low power gate micro-modules which failed to pass a proper amplitude gate pulse (GP) with standard gate micro-modules and the decoupling of the cluster input on the shift register micro-modules. In some cases faulty micro-modules were located and replaced. Subsequently, full operation was achieved with the memory stack chamber under automatic heater control by careful adjustment of V_T and -9v special supply. Acceptance test and special memory tests could be run without error but memory errors occurred when the memory stack temperature control was in operation or the stack temperature rose beyond 49°C.

Continuous machine operation was performed to isolate the cause of memory errors and ascertain the memory operating margins. Initially, most reliable operation occurred with the memory stack at room temperature and the circuitry section extended from its case. Some additional intermittent faults were located and corrected. With the circuitry section in place and the memory chamber temperature raised to its normal operating point of 40°C, it was found that the heater current on-off operation produced sufficient noise and stack temperature imbalance to affect proper memory

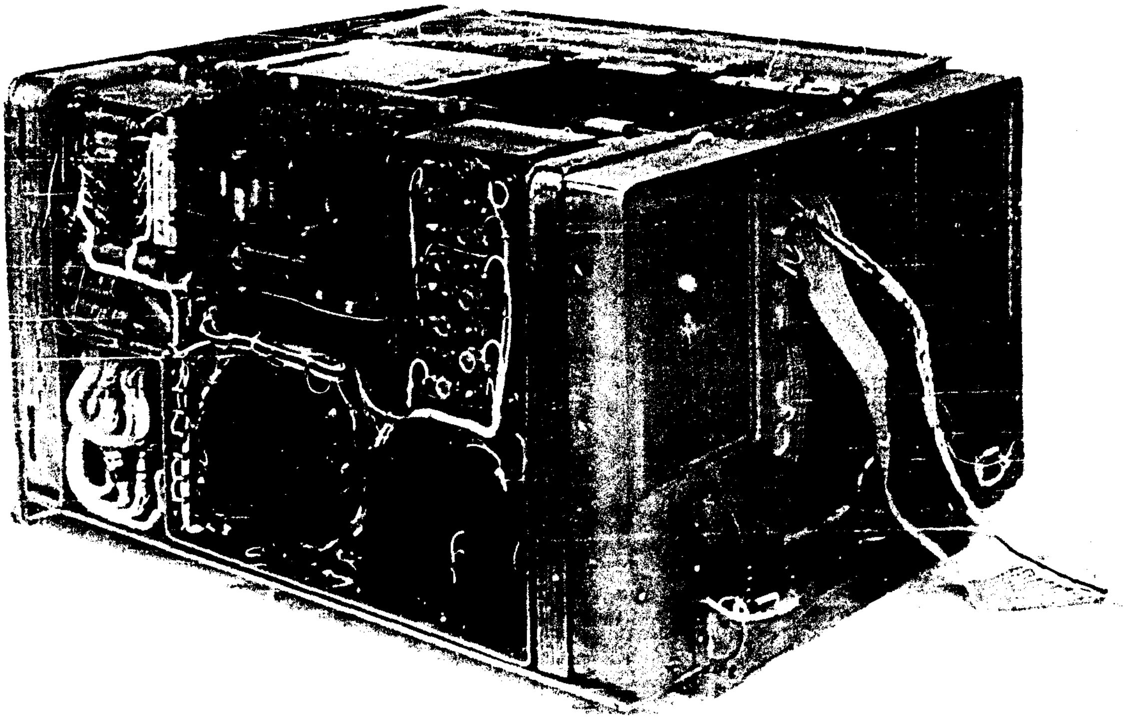


Figure 3.8-11. MicroPac Computer Main Chassis with Power Supply and Core Memory Stack Mounted

MICROPAC DIGITAL DATA COMPUTER

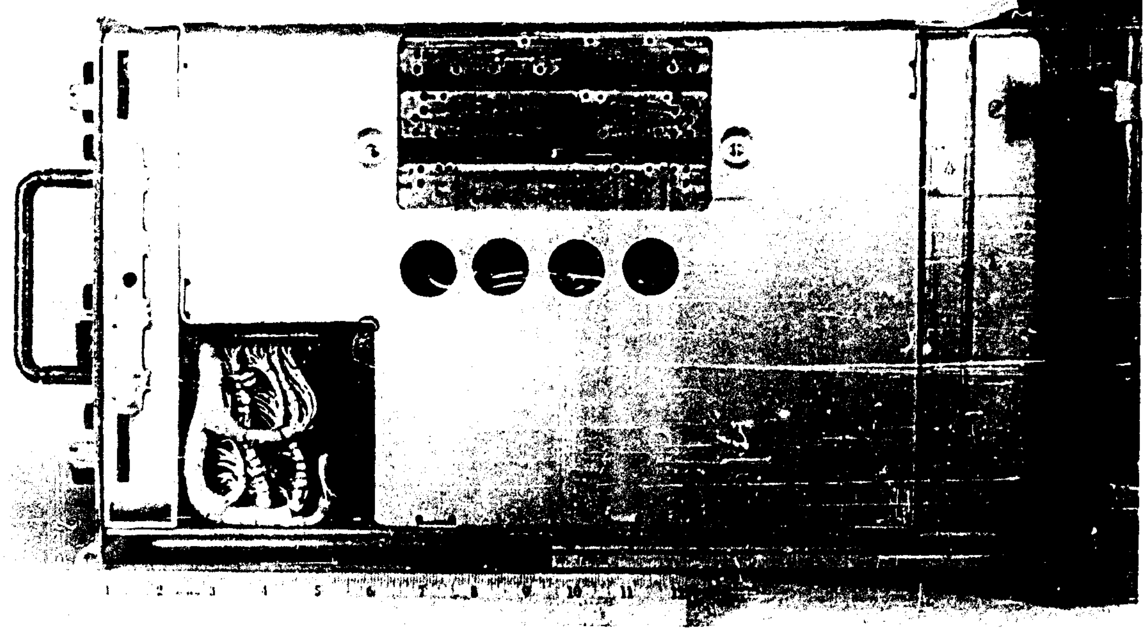


Figure 3.8-12. MicroPac, Showing Power Supply with Cover

operation. Additional filtering circuitry was added to prevent this condition. Both the low and high power heaters and the cooler were adjusted for optimum temperature control operation. With increasing temperature of the stack chamber, it was found that the operating margins of the memory system were reduced. Based upon the limited tests performed, the maximum stack temperature allowed before complete memory malfunction occurred was 54°C.

During the latter part of December, the equipment was subjected to temperature environmental tests in the test chambers. Successful operation, with the equipment extended from the case, was achieved down to 0°C. Complete equipment operation failure occurred at -30°C. This failure may have been the result of some faulty modules which were subsequently removed at the high temperature tests. The memory stack chamber was able to be maintained at a 40°C temperature at this low ambient temperature. A heater in one of the chamber walls was disconnected to permit more uniform thermal conditions. It is believed that with the equipment in the case reliable operation at the low temperature extreme may be achieved. At the high temperature end successful operation at 45°C ambient was obtained with the equipment extended from the case and supplementary power supply cooling. Trouble shooting the equipment located four marginal logic modules. The V_T and -9 special voltages were brought out under separate DC supply control from the power supply. The former controls the drive current and the latter the sense amplifier sensitivity of the memory system. Through this means, the memory voltage controls were continually altered to establish the requirements of error free operation. Above 45°C no combination of voltages could effect reliable operation.

The following is a summary of the equipment performance to date.

(A) Room Temperature Test

Equipment operated successfully outside of case in the final acceptance program.

(B) Varying Power Supply Voltage (At Room Temperature)

Equipment operated successfully outside of case in the final acceptance program.

(C) Temperature Variation Test

(1) High Temperature Ambient (Specified Requirement of $T_{Maximum}$ = 125°F (51.6°C)

(a) Low Speed Operation

Equipment operates successfully without errors at low duty cycle; i.e., data is read into and out of memory at paper tape equipment speeds (300 words per second or 1% duty cycle).

(b) High Speed Operation

Equipment operates with a memory test program but makes errors in picking up or dropping memory bits. Contributing causes of these errors may include (but are not limited) to the following:

(i) Marginal memory modules at high temperature; four marginal logic modules have previously been detected and replaced.

(ii) Memory voltages V_T (drive currents) and V_{SA} (sense amplifier sensitivity) require adjustment to establish optimum operating point.

(2) Low Temperature Ambient (Specified Requirement of $T_{Minimum}$ = -25°F (-31.6°C)

Equipment operates successfully at 0°C but does not operate at -31.6°C. No further work has been done on this test pending successful completion of high temperature test.

3.8.3 DOCUMENTATION

The final "Acceptance Test" program was submitted and approved. This document formed the basis for system testing of the computer.

During this period the following Contractual documents were delivered:

MICROPAC Computer Diagnostic Routines

Interference Reduction Plan

Recommended Spare Parts Lists

Instruction Manuals, Volumes 1, 2, and 3

All documentation has been completed except for final drawings, final report, and photographs.

3.9 SPECIFICATIONS, STANDARDS, AND RELIABILITY

3.9.1 SPECIFICATION ACTIVITY

The following table exhibits a summary of all actions relative to the specifications for the Micro-Module Program through December 31, 1962. Actions during the nineteenth quarterly period are included in the last column.

	Specifications Issued	No. of Actions to Date	Actions in 19th Quarter Only
Specifications neither amended nor revised	46	-	-
Specifications revised or amended once	19	19	1
Specifications revised or amended twice	13	26	1
Specifications revised or amended three times	19	57	-
Specifications revised or amended four times	11	44	-
Specifications revised or amended five times	10	50	-
Specifications revised or amended six times	9	54	-
Specifications revised or amended seven times	2	14	-
Gross number of revisions or amendments	-	264	3
Number of original specifications	129	129	-
Gross number of actions on specifications	-	393	3
Number of cancelled specifications	8	-	-

3.10 SUBCONTRACT ACTIVITIES

3.10.1 INTRODUCTION

Subcontract activities include administrative and technical support for the development of microelement and micro-module sources throughout industry. The subcontracting activity is responsible for evaluating both participating and prospective suppliers to insure use of the latest state-of-the-art processes and products.

3.10.2 INDUSTRY LIAISON AND SUBCONTRACT FOLLOW-UP

Supplier liaison activity was provided to assist in solving the various procedure and production facilitation problems arising during PEM preproduction and pilot-run programs on microelements and modules. Additional visits were made to coordinate vendor activities and insure proper quality and schedule performance. A tabulation of the various vendor contacts is given below.

Facilities lists for the various subcontractors were updated. Weston Instrument was visited in a preliminary move to establish final disposition of its production equipment following the end of the two-year waiting period.

A survey of metalized-alumina-substrate suppliers was made to determine availability of these parts in view of the delay at Coors Porcelain. A capability of 3000 wafers per week each for Mitronics and CFI now exists. With further investment, each can increase this rate to approximately 20,000 substrates per week within 10 weeks. Coors has indicated they will support micro-module substrate requirements with a separate silk-screen-type line until their mechanized facility is functioning.

Releases for continued effort were made to Texas Instruments, Sperry, General Electric, and CTS, who will undertake the next phase of their program. A Vendor-Signal Corps Industry Conference was conducted on September 12 and 13 at USAEMA in Philadelphia. The purpose for this conference was to enable companies participating or interested in the Micro-Module Program to discuss technical improvements and production techniques. A generally favorable reaction was obtained from the participants. Of particular benefit were the spontaneous contacts or meetings between vendors during intermissions. A transcript of the conference is being prepared for distribution to all attendees.

3.10.3 CONFERENCES (Unintentionally Omitted from the 18th Quarterly Report)

DATE	LOCATION	TASK DISCUSSED
September 12, 13	Warwick Hotel, Phila., Pa.	Micro-Module Industry

3.10.4 COMPANIES OR AGENCIES VISITED BY RCA PERSONNEL

DATE	COMPANY OR GOVERNMENT AGENCY	TASK DISCUSSED
October 1	Fort Monmouth	Diodes
November 16	Fort Monmouth	Transistors and Diodes
November 20	Fort Monmouth	Electrolytic and Trimmer Capacitors
August 29	Texas Instruments, Dallas	Transistors
November 19	Philco, Lansdale, Penna.	Transistors
November 20	Astron Co., East Newark, N.J.	Electrolytic Capacitors
October 5	Aerovox Corp., Olean, N.Y.	Multilayer Capacitors
November 6	Sprague Electric Co. North Adams, Mass.	Electrolytic Capacitors
October 17	Fairchild Semiconductor, San Rafael, Calif.	Silicon Diodes
October 23	Hughes Semiconductor Corp., Newport Beach, Calif.	Silicon Diodes
November 26 to 28	MicroSemiconductor, Culver City, Calif.	Silicon Diodes
October 17 and November 20	Midland Mfg. Co., Kansas City, Mo.	Crystals
November 1	Bulova, Woodside, N. Y.	Crystals
October 2	U. T. C., New York City, N. Y.	Inductors
October 16 and November 14	Collins Radio, Newport Beach, Calif.	Inductors
October 19	Radio Industries, Des Plaines, Ill.	Inductors
October 24	Molecular Dielectrics, Inc., Clifton, N.J.	Inductor Substrates
October 26	Delevan Electronics Corp., East Aurora, N. Y.	Inductors

DATE	COMPANY OR GOVERNMENT AGENCY	TASK DISCUSSED
October 15 and 29 to 31	Coors Porcelain, Golden, Colorado	Metalized Substrates
November 16	Mycolex Corp., Clifton, N.J.	Substrates
November 28	Mitronics, Murray Hill, N.J.	Substrates
November 29	Cores for Industry, Mineola, N.Y.	Substrates
October 4 and October 11	Victory Engineering Corp., Springfield, N.J.	Thermistors
October 16	Dale Electronics, Columbus, Nebraska	Resistors
October 18	CTS, Berne, Indiana	Semi-Precision Resistors
October 19	Microlectron, Santa Monica, California	Semi-Precision Resistors
October 19	Electra Mfg. Co., Independence, Kansas	Precision Resistors
October 8 to 9	Paktron, Alexandria, Va.	Modules
October 19 and 20	Mallory & Co., Indianapolis, Ind.	Modules
October 12	Weston Instruments, Newark, N.J.	Review Government Tooling

3.10.5 VISITORS TO RCA, SURFACE COMMUNICATIONS DIVISION, CAMDEN, N. J.

(For Discussion of Micro-Modular Concept, Techniques, and Applications)

DATE	VISITING COMPANY OR GOVERNMENT AGENCY	SURFACE COMMUNICATIONS CONTACT REPRESENTATIVE
October 2	A group of French Military Officers	J. Knoll
October 5	Mr. Victor Valentino of the Picatinny Arsenal, Dover, N.J.	D. Mackey
October 9	Representatives of the Bell Aero-system of Niagara Falls, N.Y.	D. Mackey
October 9	Representatives of the Clarostat Company, Dover, New Hampshire	D. Mackey and F. Farmer
October 10	Lt. Col. Carson, National Security Agency, Fort Meade, Md.	D. Mackey and J. Knoll and I. Grasheim
October 23	Col. Hennessy, National Security Agency, Fort Meade, Md.	J. Knoll and I. Grasheim
October 25	Representatives of Keithley Instruments of Cleveland, Ohio	D. Mackey
October 26	Maj. W. Skidmore and Mr. O. Nelson of ACSAI and Capt. R. V. Young, Fort Holabird, Baltimore, Md.	J. Knoll and I. Grasheim
October 30	Mr. Morris Groder, U. S. Navy Training Devices Center of Port Washington, L.I., New York	D. Mackey
November 14	Mr. D. W. G. Byatt of Baddow Laboratories, Marconi Wireless Telegraph Ltd. of London, England	J. Knoll
December 4	Mr. M. S. Fedida of Marconi Wireless Telegraph, Ltd. of London, England	J. Knoll
December 13	Mr. H. Freytag of Siemens and Halske Company of Munich, Germany	J. Knoll

3.10.6 VISITORS TO RCA, SOMERVILLE, N. J.

DATE	VISITING COMPANY OR GOVERNMENT AGENCY	PURPOSE OF VISIT
October 9	Bell Aerosystem, Niagara Falls, N.Y.	Discussion of Micro-Modules
October 25	Keithly Instrument, Cleveland, Ohio	Discuss Micro-Module Program
November 1	Hughes Aircraft, Culver City, Calif.	Micro-Module Discussion

4. CONCLUSIONS

4.1 CAPACITORS

Aerovox has demonstrated performance and production capability of at least 7000 per month for multilayer capacitors types from NPO to N2200.

Centralab's preproduction data indicate a need for improved quality by the vendor and for a review of the PEM specifications prior to the start of pilot-run production.

The equipment improvements being made by Coors Porcelain indicate that consistently good metalized substrates can be fabricated.

4.2 RESISTORS

On the basis of performance during the analysis phase of the PEM, CTS Corporation and Microlectron were selected for production facilitation for a broad range of micro-element cermet resistors.

Under load life tests of small lots of precision resistors made by four manufacturers, the resistors of Electra Manufacturing Company showed the smallest change in resistance at various lengths of time up to a maximum of 2000 hours. These resistors are stock items which have indicated a capability for use in micro-modules.

Semi-precision resistors made by CTS Corporation showed a maximum resistance change of only 0.84 percent after 2000 hours of load-life test as compared with a specified tolerance of ±2 percent. Only 1.4 percent of 2500 similar resistors made by Microlectron were rejected in Group A tests made on a 100 percent basis.

4.3 INDUCTORS

Life tests on Aladdin pulse transformers indicate further improvement is needed in insulation resistance to assure reliability.

Delevan has successfully completed its task on low frequency module-size inductors and has established a production capability for this unit.

Radio Industries has demonstrated a capability for producing i-f trimmer-inductor elements made with commercial-grade ferrites.

Cambridge Thermionic has shown a capability to fabricate final-grade high-frequency "D" core fixed elements. Cambion's cost projection indicates that the "D"-type core is an economical construction.

The deep-glass-bonded-mica substrate has been shown to be compatible with the RCA header assembly method.

4.4 SEMICONDUCTORS

Two hundred units each of the 2N705 Germanium Mesa transistors and the 2N328A Silicon Alloy Junction Transistors, fabricated, respectively, by Texas Instruments and Sperry Semiconductor, have successfully met all Phase II requirements of PEM Task 31.

After overcoming trouble with faulty stems for the TO-46 package, Philco has finished Phase I and is completing Phase II of Task 31 with the fabrication and testing of 200 samples of each of type 2N501A Germanium transistors and type 2N495 Silicon transistors.

Specified requirements were met by the RCA Silicon TA-2029 VHF Power Transistor tested with controlled case temperature. Three hundred RCA Germanium TA-2229 transistors have been fabricated and are in aging tests.

Fifty 2N335 Grown Junction Silicon Transistors, made by the General Electric Company, met all hermeticity requirements and are compatible with micro-module processing techniques.

Phase I of their PEM diode assignments under Task 32 and also all testing required for Phase II have been successfully completed by Fairchild, Hughes, and MicroSemiconductor, Inc.

4.5 MATERIALS

The long-cure cycle can be used on encapsulated deep inductor substrates with no adverse effects from thermal cycling. This curing procedure is also recommended for Stycast 2651-140.

4.6 MICRO-MODULES

Most of the module assembly facilities have been installed and are presently being modified and refined where necessary. Mallory and Paktron indicate they will have production capabilities by March 1, 1963.

4.7 EQUIPMENT

After having successfully met all requirements of the specified acceptance tests, all transmitters and receivers of the thirteen required AN/PRC-51 Radio Sets were delivered to the Signal Corps during this quarterly period.

During this report period, the MicroPac Computer was completely assembled and tested in the performance of all its logic and system functions. Full acceptance test programs have been run successfully at room temperature. Although the MicroPac computer performed satisfactorily in all modes, further system test effort is required to extend the operation over the full environmental temperature range as specified in Signal Corps Technical Requirements SCL-429.

5. PROGRAM FOR THE NEXT QUARTER

5.1 ADMINISTRATION

Close monitoring of all PEM program progress will be continued with major management effort applied to expediting the completion of the various tasks.

5.1.1 DESIGN PLANS

Only minor revisions of design plans are anticipated. Should a need for further modifications be disclosed by the continued close monitoring of the over-all program, such changes will be effected through the established approved procedures.

5.1.2 PROGRESS CHARTS

The submission of Technical and Financial Progress Charts will be continued on the current monthly basis.

5.1.3 REPORTS

The 19th Quarterly Report, covering the period from October 1 through December 31, 1962, and the Monthly Letter Progress Reports for December 1962, January and February, 1963, will be prepared and submitted. Instruction booklets and the final report on the AN/PRC-51 Radio Set will be completed. The latter report is to be combined with the S&MD report on micromodules used in the AN/PRC-51 (Task 25A) and the integrated result delivered as the Formal Engineering Report on the modules and the radio set (Tasks 25A and 27A). Work on the integrated report will be well advanced by the end of the next quarter.

The Proceedings of the Micromodule Industry Conference (Philadelphia, September 12, 13, 1962) will be published.

Work will continue on preparation of the Micromodule Design and Application Guide, a draft of which will be submitted to the Signal Corps before the end of the next quarter.

5.2 PASSIVE COMPONENTS

5.2.1 CAPACITORS

Cornell-Dubilier will complete fabrication of pilot-run parts and continue acceptance testing. Aerovox will continue fabrication of pilot-run parts, and an engineering meeting will be held to witness a demonstration of acceptance testing and facility capability. Aerovox will also complete the preproduction moisture resistance test,

continue extended life testing of the multilayer capacitor samples of the analysis phase, and continue work on the extended temperature coefficient range program.

Under the electrolytic capacitor subtask, Astron and Sprague will fabricate preproduction samples. Upon approval of the test facilities, these subcontractors will initiate preproduction testing.

Centralab's preproduction program and PEM specifications for variable ceramic capacitors will be reviewed prior to the start of the pilot-production phase.

Coors Porcelain will continue the fabrication of preproduction capacitor samples for module requirements along with improvement of the substrate metalizing facilities.

5.2.2 RESISTORS

The Electra precision resistors will be mounted on substrates with one 30 ohm and one 100,000 ohm resistor on each wafer. Qualification testing will be conducted on these parts in accordance with RCA Specification A-8972063 - Characteristic A.

Paktron will remake the qualification samples of utility resistors and start testing.

Microelectron will continue pilot-run tests and CTS will start pilot-run production and testing.

5.2.3 INDUCTORS

Aladdin will complete all testing and analysis of final-grade 01-717 pulse transformers. They will also prepare a draft of the final report.

The final report on adjustable low-frequency reactor modules will be reviewed by RCA and submitted to the Signal Corps. This action will complete the Delevan subtask.

Collins will submit prototype samples of both medium and high frequency fixed inductor microelements. Fabrication will begin when approval is obtained.

Approval of Radio Industries prototype i-f-trimmer inductor elements is anticipated. Final-grade samples will be fabricated and Group A, B, and C tests initiated.

Group B and C tests will be started on the "D" core inductor microelements.

United Transformer will complete the audio transformer and top-element choke subtask.

The new 16 cavity mold will be completed by Molecular Dielectrics.

5.3 SEMICONDUCTOR DEVICES

5.3.1 TRANSISTORS

Texas Instruments and Sperry will complete the 1000-hour aging of the Phase III preproduction test samples. They will also initiate Phase III acceptance testing to demonstrate conformance to specifications.

Philco will complete 1000-hour aging and all Group A and B testing on 200 type 2N501A germanium and 50 type 2N495 silicon engineering test sample transistors which are required for the Phase II effort.

RCA will complete Phase II testing of the 400 mw, 70 mc unit. After final inspection, its Phase III preproduction run will be started.

Phase II qualification testing on TA-2029 and TA-2229 germanium types will be completed, and final specifications negotiated.

General Electric will complete 1000-hour aging and initiate Phase II qualification testing on the 2N335 silicon grown-junction transistor.

A test program for ultrasonic cleaning of semiconductor devices will be completed.

5.3.2 DIODES

A final specification for the 1N658 silicon diode microelement will be submitted for approval, and Fairchild and Micro Semiconductor will begin the Phase III effort.

Hughes will proceed into Phase III and fabricate 300 1N750A Zener diode preproduction test samples. The new welding head design will be built during the next quarter.

5.4 CRYSTALS

Midland Manufacturing Company will complete its preproduction run and deliver crystal units to Victor Electronics for initiation of preproduction testing. Isotronics will continue its fabrication of crystal packages for Bulova Electronics. Bulova will fabricate fifteen analysis phase sample crystal units.

5.6 MICRO-MODULES

5.6.1 ASSEMBLY AND TEST

Life testing will continue on the remaining 99 Task 25A modules. Evaluation of Group B and C test data will start as soon as the respective specifications are established.

Assembly and test of all modules for the MicroPac Computer (Task 25B) will be completed.

5.6.2 MICRO-MODULE ASSEMBLY

a. Installation of all module assembly facilities will be completed and fabrication of preproduction modules will be initiated.

b. Follow-up of Mallory and Paktron preproduction modules under Task 36-4 will be continued. The preproduction run was scheduled to start February 1, 1963.

c. Work will be started on pilot-run modules (Task 39-1). Work statements will be prepared and bids solicited for subcontractor pilot-run modules under this task.

5.6.3 RELIABILITY

Reject Analysis will continue on AN/PRC-51 and MicroPac Computer micro-modules from production and customer returns. Procedures will be written for Reject Analysis and Design Review.

5.7 AN/PRC-51 RADIO SET

Instruction booklets and the final report for this equipment will be completed and delivered to the Signal Corps.

5.8 MICROPAC COMPUTER

With the equipment completely assembled in its transit case, the acceptance test will be performed at room temperature.

The cause for unsatisfactory operation of the memory will be investigated, faulty modules will be removed and the memory control currents will be adjusted.

If time permits, testing at the specified temperature extremes will be repeated.

All documentation will be completed.

5.9 SPECIFICATIONS, STANDARDS, AND RELIABILITY

During the next quarter, additional microelement and module specifications for the PEM Phase of Program Extension II will be issued as required.

6. PUBLICATIONS AND REPORTS

6.1 MONTHLY LETTER PROGRESS REPORTS

During this quarterly period, the following monthly reports were completed and issued:

Fifty-fourth Monthly Report, September, 1962

Fifty-fifth Monthly Report, October, 1962

Fifty-sixth Monthly Report, November, 1962

6.2 FORMAL REPORTS

The Formal Engineering Reports on Transistors and Diodes (Task 18 and 19), respectively of Program Extension I, were completed and sent to the printer.

Preparation of the Eighteenth Quarterly report was continued.

A Status Report of the Production Engineering Measure on Micro-Modules was completed and submitted.

6.3 PUBLICATIONS

A brochure entitled, "The Micro-Module Approach to Field Retrofit", directed toward the RCA Field Service Engineers was prepared, printed, and distributed.

7. BIOGRAPHIES OF KEY PERSONNEL

Biographies of most of the key personnel of the Micromodule Program have been presented in previous reports. Those given below pertain to persons who either have joined the program recently or were inadvertently omitted from previous reports.

7.1 SURFACE COMMUNICATIONS DIVISION, DEP

MR. SAUL STIMLER, Manager, Engineering (Micro-Module Projects), received his Bachelor of Electrical Engineering Degree from the College of the City of New York in 1942.

From 1942 to 1944 Mr. Stimler was employed as a junior engineer with the General Electric Company in Schenectady, New York. During this period he worked on a microwave receiver and transmitter and with video equipment.

From 1944 to 1945 he was employed as an electronic engineer, designing railway signal equipment for Union Switch and Signal Company in Swissvale, Pa.

As an instrument observer for Seismograph Service Company in South America from 1945 to 1948, he operated and maintained seismograph instrumentation in the field.

From 1948 to 1955, Mr. Stimler was a supervisory electrical engineer at the U. S. Naval Ordnance Laboratories at White Oak, Maryland. Here he designed and developed electronic instrumentation for recording underwater sounds, and supervised the design, development, and engineering evaluation of new acoustic mine firing mechanisms. He also developed techniques and aids to assist the mining officers to obtain optimum tactical employment of an advanced weapon system.

From 1955 to 1958, as Product Line Manager for Minneapolis-Honeywell, he was in charge of the Control Instrumentation for the Nuclear Reactor and of the magnetic recording head product lines. He also was project engineer on the BOMARC missile gas charging system and the Combustion Engineering Critical Facility instrumentation.

During 1958 to 1961 at ITT Federal Laboratories in Nutley, N. J., he was staff engineer to the Director of Digital Systems Laboratories, responsible for magnetic tape system integration into the ITT bank computer. He also assisted in the computer check-out program.

Mr. Stimler has been in the employ of the Radio Corporation of America from 1961 to the present time. In the Major Systems Division at Moorestown, he was responsible for new system studies, particularly as applicable to tactical Army problems, and for management of proposal efforts requiring multi-divisional coordination. Presently, he is Manager of Micro-Module Projects in the Micro-Module Programs Section of the Surface Communications Division. In this capacity he is active in developing applications for advanced micromodular techniques and in the management of contracts requiring microminiaturization.

Mr. Stimler is a member of TAU BETA PI, ACM, AOA, AFCEA. He holds two patents and the Navy's Meritorious Civilian Service Award.

8. HOURS OF WORK PERFORMED BY RCA PERSONNEL

8.1 SURFACE COMMUNICATIONS DIVISION

Engineers	October	November	December	Total
W. Adelman	-	184	40	224
F. Bennett	144	28	-	172
M. Bondy	138	165	111	414
F. Brennan	160	217	132	509
P. Carides	174	176	179	529
R. Colton	166	236	214	616
J. Donoghue	152	184	124	460
F. Farmar	168	184	116	468
W. Grossman	94	109	68	271
S. Heller	144	176	136	456
R. Higgins	160	192	140	492
G. Hughes	110	56	-	166
A. Rettig	122	156	230	508
G. Rezek	24	204	176	404
L. Scharff	168	204	178	550
J. Smiley	172	223	190	585
P. Taylor	160	168	140	468
K. Weir	160	186	156	502
J. Yelverton	160	224	219	603
Others	287	84	357	728
TOTAL ENGINEERS	2,863	3,356	2,906	9,125

Technicians	October	November	December	Total
D. Barrett	160	56	-	216
J. Davis	203	148	32	383
L. Halpern	160	40	-	200
J. Jackson	160	200	194	554
C. Mehl	152	208	24	384

Technicians	October	November	December	Total
R. Moyer	160	216	180	556
H. O'Donnell	131	108	-	239
A. O'Hara	142	184	140	466
R. Walukonis	144	179	164	487
F. Weigert	136	159	-	295
Others	194	326	3	523
TOTAL TECHNICIANS	1,742	1,824	737	4,303

8.2 SEMICONDUCTOR AND MATERIALS DIVISION

Engineers	October	November	December	Total
J. DiMauro	152	156	156	464
R. DiStefano, Jr.	-	50	132	182
J. Eisenhardt	-	133	156	289
R. Fresyzloa	123	148	126	397
G. Hauser	183	158	138	479
I. Hintikka	134	58	4	196
L. Huis, Jr.	136	92	-	228
H. Keitelman	167	160	142	469
D. Levy	136	104	138	378
W. Lowden	134	101	44	279
M. Mitchell	104	104	69	277
P. Nyul	165	117	125	407
J. O'Toole	80	72	60	212
T. Passwater	180	152	133	465
W. Paterson	192	128	120	440
C. Peters	120	104	88	312
R. Petrina	108	46	64	218
J. Pirkey	181	164	125	470
R. Rosenfeld	176	160	149	485
H. Scheffer	-	124	128	252

Engineers	October	November	December	Total
T. Spitz	90	58	103	251
D. Stubbins	93	96	31	220
J. Sundberg	180	157	144	481
Others	222	261	197	780
TOTAL ENGINEERS	3,056	2,903	2,672	8,631
Technicians				
J. Cambria	144	160	-	304
R. Cassaro	172	163	160	495
J. Charney, Jr.	69	46	44	159
R. Clark, Jr.	176	155	130	461
W. Drake	97	120	131	348
D. Espinal	56	64	86	206
H. Foxman	118	44	12	174
D. Hansenzahl	176	156	96	428
J. Harken	99	49	32	180
L. Hart	-	36	120	156
F. Heiselman	42	156	70	268
E. Magrosky	162	160	133	455
R. Monaco	184	156	130	470
S. Peachey	156	150	154	460
C. DiRitis	111	102	46	259
S. Shwartzman	158	154	150	462
D. Stoller	176	168	40	384
J. Swentzel	192	134	32	358
P. Trench	140	100	120	360
M. Weisberg	164	164	163	491
H. Witmer	88	59	58	205
Others	354	268	294	916
TOTAL TECHNICIANS	3,034	2,764	2,201	7,999

8.3 HOURS OF WORK

October 1 through December 31, 1962

8.3.1 SURFACE COMMUNICATIONS DIVISION

Engineers	9,125
Technicians	4,303

8.3.2 SEMICONDUCTOR AND MATERIALS DIVISION

Engineers	8,631
Technicians	7,999

8.3.3 TOTAL HOURS 30,058

9. CORRECTIONS FOR EIGHTEENTH QUARTERLY REPORT

NOTE: The editors would appreciate notification of errors in the latest quarterly report so that corrections may be listed in the succeeding reports. These may be sent to:

Radio Corporation of America
Surface Communications Division
Building 1-4-3
Camden 2, New Jersey
Attention: Dr. P. K. Taylor,
Engineering Editor

9.1 SPECIFIC CORRECTIONS

Page	Location	Nature of Correction
3-40	3rd sentence of paragraph d, next to the last line on the page	Replace with the following: The related work statement has been revised to expand the families of devices by including transistor types TA-2029 and TA-2229 in MMDP-32-4
3-69	Title of Section 3. 7. 1	Change the word "Ratio" to "Radio"
3-79	Table 3. 7-10	Add the missing model number, "Prototype Model No. 9"
5-3	Section 5. 3. 1. 2, 1st sentence	Change the wording after "Phase III" to: "of the programs for the 2N328A and 2N705 transistors"
5-3	Section 5. 3. 1. 2, 3rd line	Change "and" to afterwhich"
5-3	Section 5. 3. 1. 2, 4th line	Change " , and proceed into" to "for use in"
5-5	Section 5. 8 Title	Change to "The MicroPac Computer"

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